



Cochrane
Library

Cochrane Database of Systematic Reviews

Exercise interventions for smoking cessation (Review)

Ussher MH, Taylor A, Faulkner G

Ussher MH, Taylor A, Faulkner G.

Exercise interventions for smoking cessation.

Cochrane Database of Systematic Reviews 2008, Issue 4. Art. No.: CD002295.

DOI: 10.1002/14651858.CD002295.pub3.

www.cochranelibrary.com

TABLE OF CONTENTS

HEADER	1
ABSTRACT	1
PLAIN LANGUAGE SUMMARY	2
BACKGROUND	2
OBJECTIVES	3
METHODS	4
RESULTS	4
DISCUSSION	6
AUTHORS' CONCLUSIONS	10
ACKNOWLEDGEMENTS	11
REFERENCES	11
CHARACTERISTICS OF STUDIES	21
DATA AND ANALYSES	38
Analysis 1.1. Comparison 1 Exercise component versus smoking cessation programme only, Outcome 1 Smoking cessation at longest follow up.	38
APPENDICES	39
WHAT'S NEW	47
HISTORY	47
CONTRIBUTIONS OF AUTHORS	48
DECLARATIONS OF INTEREST	48
SOURCES OF SUPPORT	48
INDEX TERMS	49

[Intervention Review]

Exercise interventions for smoking cessation

Michael H Ussher¹, Adrian Taylor², Guy Faulkner³

¹Division of Population Health Sciences and Education, St George's, University of London, London, UK. ²School of Sports & Health Sciences, University of Exeter, Exeter, UK. ³Faculty of Physical Education and Health, University of Toronto, Toronto, Canada

Contact address: Michael H Ussher, Division of Population Health Sciences and Education, St George's, University of London, Cranmer Terrace, London, SW17 0RE, UK. m.ussher@sgul.ac.uk.

Editorial group: Cochrane Tobacco Addiction Group.

Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 11, 2011.

Citation: Ussher MH, Taylor A, Faulkner G. Exercise interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 2008, Issue 4. Art. No.: CD002295. DOI: 10.1002/14651858.CD002295.pub3.

Copyright © 2011 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.

ABSTRACT

Background

Taking regular exercise may help people give up smoking by moderating nicotine withdrawal and cravings, and by helping to manage weight gain.

Objectives

To determine whether exercise-based interventions alone, or combined with a smoking cessation programme, are more effective than a smoking cessation intervention alone.

Search methods

In July 2011, we searched the Cochrane Tobacco Addiction Group Specialized Register for studies including the terms 'exercise' or 'physical activity'. We also searched MEDLINE, EMBASE, PsycINFO, Dissertation Abstracts and CINAHL using the terms 'exercise' or 'physical activity' and 'smoking cessation'.

Selection criteria

We included randomized trials which compared an exercise programme alone, or an exercise programme as an adjunct to a cessation programme, with a cessation programme, recruiting smokers or recent quitters, and with a follow up of six months or more.

Data collection and analysis

We extracted data on study characteristics and smoking outcomes. Because of differences in studies we summarized the results narratively, making no attempt at meta-analysis.

Main results

We identified 15 trials, seven of which had fewer than 25 people in each treatment arm. They varied in the timing and intensity of the smoking cessation and exercise programmes. Three studies showed significantly higher abstinence rates in a physically active group versus a control group at end of treatment. One of these studies also showed a significant benefit for exercise versus control on abstinence at the three-month follow up and a benefit for exercise of borderline significance ($p = 0.05$) at the 12-month follow up. One study showed significantly higher abstinence rates for the exercise group versus a control group at the three-month follow up but not at the end of treatment or 12-month follow up. The other studies showed no significant effect for exercise on abstinence.

Authors' conclusions

Only one of the 15 trials offered evidence for exercise aiding smoking cessation at a 12-month follow up. All the other trials were too small to reliably exclude an effect of intervention, or included an exercise intervention which was insufficiently intense to achieve the desired level of exercise. Trials are needed with larger sample sizes, sufficiently intense interventions, equal contact control conditions, and measures of exercise adherence and change in physical activity in both exercise and comparison groups.

PLAIN LANGUAGE SUMMARY

Do exercise interventions help people quit smoking

Exercise is routinely recommended as an aid to smoking cessation by specialist clinics and self-help materials. Fifteen trials have compared an exercise programme plus a smoking cessation programme, or an exercise programme alone, to a cessation programme alone or a cessation programme plus a health education programme, among smokers who were motivated to quit. Since these studies used different types of exercise programmes, and varied in the duration of follow up, the results were not combined. In one study with a difference in quit rates of borderline significance, the exercise component more than doubled the likelihood of not smoking after 12 months.

BACKGROUND

Cigarette smoking is an important risk factor for cardiovascular disease, cancer and hypertension, and is one of the major causes of premature mortality in industrialized nations (Doll 2004; Peto 1996). Stopping smoking prolongs life and reduces morbidity (USDHHS 1990; Taylor 2002). Many attempts to stop smoking are made unaided (West 1997; Hughes 2004), with a success rate (6 to 12 months prolonged abstinence) of around 3 to 5% (Hughes 2004). Aided quit attempts, particularly through a combination of behavioural counselling and nicotine replacement therapy (NRT), bupropion or varenicline can improve success rates, but these remain low (Cahill 2011; Hughes 2007; Stead 2008). More effective smoking cessation interventions are needed.

Effect of exercise on tobacco withdrawal and cravings

Exercise has been proposed as an aid for smoking cessation (Hill 1981). In this review the terms exercise and physical activity (PA) are used interchangeably and refer to both 'lifestyle' physical activities, such as walking, as well as more formal structured activities, such as using a stationary cycle. The severity of 'desire to smoke' reliably predicts relapse in smokers who are trying to stop (Doherty 1995; West 1989) and interventions are required which reduce the desire to smoke. In experimental studies, cardiovascular-type exercise has been shown to have an acute effect on reducing both psychological withdrawal symptoms and desire to smoke in absti-

nent smokers. This has been shown to be the case for both brief (5 to 10 minute) bouts of moderate intensity exercise among smokers who have been abstinent overnight and for 30 to 40 minute bouts of vigorous intensity among smokers who are trying to quit smoking (Taylor 2007b, also see the table of acute studies in the appendix). The mechanism underlying the observed beneficial effect of exercise on withdrawal and cravings is not clear. Exercise has been shown to have some similarities to smoking in its effects on stimulating the central nervous system (Russell 1983) and on neurobiological processes in the brain (Dishman 2009), including increasing beta-endorphin levels in smokers (Leelarungrayub 2010), and consequently it has been argued that exercise may provide an alternative reinforcer to smoking (Marlatt 1985). This argument is consistent with behavioural theories of choice (Correia 1998) and animal studies have demonstrated that exercise is an effective alternative reinforcer to illicit substances for rats (e.g. Cosgrove 2002), but no studies could be identified which have investigated the role of exercise as an alternative reinforcer to smoking. It seems plausible that the attention to somatic cues during exercise presents a unique strategy for distracting smokers from the cravings and negative cognitions experienced during smoking abstinence, although the findings from one study suggest that distraction is unlikely to play a major role (Daniel 2006). Another possible mechanism is that exercise influences cognitive functioning in smokers; for example, exercise appears to reduce attentional bias to smoking images (Janse van Rensburg 2009a).

Besides the potential benefits of exercise for moderating psychological withdrawal symptoms and cravings, exercise has also been

shown to reduce post-smoking cessation weight gain for up to two years following cessation (Parsons 2009; Kawachi 1996). The weight control benefits of exercise may be of particular importance to female smokers who report smoking to control weight (USDHHS 2001; Weekley 1992), and report fear of post-cessation weight gain as a motivation for continued smoking (Clark 2004; Sorenson 1992; USDHHS 2001) and for smoking relapse (Gritz 1989; Klesges 1992). Exercise has also been shown to have a positive effect on other factors that may protect against smoking relapse, including perceived coping ability (Steptoe 1989) and self-esteem (Spence 2005). In addition, being physically active has many general health benefits (Garber 2011), which have been observed for smokers who have quit (Albrecht 1998; Niaura 1998; Shinton 1997) and for continuing smokers (Colbert 2001; Hedblad 1997; Senti 2001). Moreover, a review suggests that participation in regular physical activity satisfies eight of the principles characterising a tobacco harm reduction strategy (deRuiter 2006). For example, one study observed that physical activity levels were inversely associated with lung carcinoma among current and former smokers (Leitzmann 2009).

Associations between exercise and smoking behaviours

Evidence from a number of large cross-sectional surveys indicates that levels of PA are inversely related to smoking rates (e.g. Boutelle 2000; Boyle 2000; Hu 2002; Picavet 2010; Schuman 2001; Takemura 2000). Other evidence from cross-sectional studies suggests that this relationship may be influenced by both gender and mode of PA. For example, when only examining leisure-time PA, heavy smoking has been shown to be inversely related to PA in men but not in women (Schroder 2003). Elsewhere, participation in sport has been negatively associated with smoking in men but not in women (Helmert 1994). Additionally, some earlier studies have shown a weak relationship or no relationship between PA and smoking (Blair 1985; King 1992).

We only found one study (Sasco 2002) which examined the relationship between smoking and exercise in pre-adolescents; and this cross-sectional study reported a positive association between engaging in PA and 'ever smoking'. Among adolescents, cross-sectional studies have consistently shown that smoking is negatively associated with participation in sport (Escobedo 1993; Peretti-Watel 2003; Rodriguez 2004; Rodriguez 2008;) and with overall levels of PA (Coulson 1997; Pate 1996; Verkooijen 2008; Ward 2003). There is some evidence to suggest that this pattern may be different for boys versus girls and some of the evidence is contradictory. For example, a cross-sectional study of adolescents found a negative association between sporting activity and smoking for boys and heavy smoking, but not for girls or for lighter smokers (Peretti-Watel 2002). Another study observed no association between sports participation and smoking levels in males (Davis 1997), while a prospective study found that leisure-time

PA was positively associated with initiating smoking for girls but not for boys (Aaron 1995). Two prospective studies found that higher levels of PA reduced the odds of starting smoking for boys and girls both during childhood (Audrain-McGovern 2003) and adulthood (Kujala 2007). One study showed that the negative association between physical activity and smoking is mediated by having a physically active identity (Verkooijen 2008). A detailed review of studies examining associations between smoking and physical activity has been published by Kaczynski 2008.

Smokers trying to quit are likely to be more receptive to an active lifestyle than smokers in general (Doherty 1998; King 1996). Smokers report that they value exercise as a strategy for reducing the risk of developing tobacco-related disease (Haddock 2004), and higher levels of exercise are associated with less depression in smokers (Vickers 2003; Williams 2008). Being physically active has been positively associated with initiating a quit attempt (Haddock 2000; deRuiter 2008), with confidence to maintain smoking abstinence (King 1996) and with success at stopping smoking (Derby 1994; Paavola 2001; Sedgwick 1988; Abrantes 2009), although one large survey found no association between exercise levels and intention to quit smoking (Nguyen 1998). Other work shows a positive trend between avoiding relapse to smoking and physical health and fitness (Metheny 1998) and a significantly reduced risk of smoking relapse among those who are more physically active (McDermot 2009).

Overall, from the above evidence one might hypothesize that pursuing regular exercise during an attempt to stop smoking could act both to reduce nicotine withdrawal symptoms and cravings and to increase rates of smoking cessation. In practice, exercise has for many years been routinely recommended as an aid to smoking cessation by specialist smoking clinics (e.g. Hurt 1992; Everson 2010), by pharmaceutical companies (e.g. Boots 1998), in self-help guides (Ashelman 2000; Marcus 2004) and in national guidelines (e.g. Quit 1994; Woodhouse 1990; USDHHS 2008), and many smokers are likely to view physical activity as an aid to quitting (Everson-Hock 2010a). In the short term, most smokers are unlikely to spontaneously increase their levels of PA after quitting (Allen 2004; Hall 1989; Vander Weg 2001), and the present review examines studies which have evaluated exercise interventions as an aid to smoking cessation.

This updated review builds on a previous report (Ussher 2000a). We also note the results of a review which included a meta-analysis using three of the studies identified in the current review and two further studies which had an exercise-only intervention (Nishi 1998).

OBJECTIVES

The objective of the present review was to establish whether exercise-based interventions alone, or combined with a smoking ces-

sation programme, are more effective than a smoking cessation intervention alone.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized controlled trials.

Types of participants

Smokers wishing to quit or recent quitters.

Types of interventions

Programmes of supervised or unsupervised exercise alone or as an adjunct to a smoking cessation intervention, compared with a smoking cessation programme alone. Interventions which included exercise in a multiple component smoking cessation programme were excluded since the specific effects of exercise on smoking abstinence could not be addressed. Multiple risk factor interventions where smoking cessation was one of a number of health-related outcomes were excluded for the same reason.

Types of outcome measures

Smoking cessation at the longest follow up reported. Trials with less than six months' follow up were not included (i.e. a study was included if follow up was at least six months post-baseline, six months post-quit or six months post-treatment).

Search methods for identification of studies

We searched the Specialized Register of the Cochrane Tobacco Addiction Group for studies including 'exercise' or 'physical activity'. We also searched MEDLINE, Pubmed, EMBASE, PsycINFO, Dissertation Abstracts and CINAHL, using the terms 'smoking', 'smoking cessation', 'exercise', 'physical activity' and 'intervention' (searches completed July 2011). We also carried out a hand search of reference lists and conference abstracts, conducted additional searches on key authors and contacted key authors.

Data collection and analysis

We extracted the following data from each study report: study design, recruitment and randomization method; subject characteristics including age, gender, smoking behaviour, exercise levels at entry; sample size; description of exercise and smoking cessation programmes (including number of sessions and duration); rates of exercise adherence; control conditions; length of follow up; definition of cessation; method of validation. The primary outcome was quitting at longest follow up using the strictest definition of abstinence reported in the study.

Due to the small number of studies, small sample sizes and differences in study design and intervention, we did not conduct a meta-analysis. For each study the risk ratio for quitting at longest follow up and the 95% confidence interval were displayed graphically.

RESULTS

Description of studies

The literature search identified 15 studies which met the inclusion criteria. Full details for each study are given in the [Characteristics of included studies](#) table. Six studies had more than one associated publication or abstract ([Bize 2010](#); [Kinnunen 2008](#); [Marcus 1999](#); [Marcus 2005](#); [Prapavessis 2007](#); [Ussher 2003](#)) and these are listed under the study identifier in the reference section. Seven trials had fewer than 25 people in each treatment arm ([Ciccolo 2011](#); [Hill 1985](#); [Hill 1993](#); [Marcus 1991](#); [Marcus 1995](#); [Russell 1988](#); [Taylor 1988](#)). Seven trials were limited to women ([Kinnunen 2008](#); [Marcus 1991](#); [Marcus 1995](#); [Marcus 1999](#); [Marcus 2005](#); [Prapavessis 2007](#); [Russell 1988](#)), and one to men ([Taylor 1988](#)). In all but two of the studies ([McKay 2008](#); [Taylor 1988](#)) a multi-session cognitive behavioural smoking cessation programme was provided for intervention and control conditions. In six studies this began prior to quit day ([Hill 1993](#); [Kinnunen 2008](#); [Marcus 1999](#); [Marcus 2005](#); [Prapavessis 2007](#); [Ussher 2003](#)). One study provided only a single session cessation programme and participants were post-acute myocardial infarction (AMI) patients, with the intervention being for relapse prevention ([Taylor 1988](#)). One study delivered a smoking cessation programme via the Internet and this was only available for the non-exercise condition ([McKay 2008](#)). Four studies included nicotine patches as part of the smoking cessation programme ([Ciccolo 2011](#); [Marcus 2005](#); [Prapavessis 2007](#); [Ussher 2003](#)), one study used nicotine gum ([Kinnunen 2008](#)) and two promoted nicotine replacement therapy in general ([Bize 2010](#); [McKay 2008](#)).

Twelve of the studies recruiting current smokers set a quit date, and one set a quit date for the non-exercise condition but did not specify whether the exercise group set a quit date ([McKay 2008](#)). The

exercise programme began before the quit date in nine studies (Bize 2010; Hill 1993; Kinnunen 2008; Marcus 1991; Marcus 1995; Marcus 1999; Marcus 2005; Prapavessis 2007; Ussher 2003) on the quit date in three (Ciccolo 2011; Hill 1985; Martin 1997), after the quit date in two (Russell 1988; Taylor 1988) and one study did not state the timing of the exercise programme (McKay 2008). Two studies entailed exercise programmes lasting for less than six weeks (Hill 1985; Martin 1997) and the length of one programme was not given (McKay 2008). Most of the trials employed supervised, group-based cardiovascular-type exercise supplemented by a home-based programme. Four studies did not provide a home programme (Ciccolo 2011; Marcus 1991; Marcus 1995; Marcus 1999), one study used only brief one-to-one counselling towards pursuing home-based exercise (Ussher 2003), and one provided a web-based program designed to encourage engagement in a personalized fitness program although specific detail was not provided regarding the type of exercise promoted (McKay 2008). Ciccolo 2011 focused exclusively on an individual programme of resistance exercise (i.e. weight training).

Excluded studies

The literature search revealed a number of trials which did not satisfy the inclusion criteria (see [Characteristics of excluded studies](#) table), but had exercise as an independent variable and smoking cessation behaviour as a dependent variable. These studies mainly fell into four categories:

- (a) Multiple independent and dependent variables: a number of studies were identified in which exercise was one element in a multiple risk factor intervention, with smoking cessation behaviour as one of a number of health-related outcomes. The specific effects of exercise on smoking cessation could not be determined due to possible interaction and confounding between the independent variables. For example, it is not possible to separate the effects on smoking cessation due to a change in diet versus a change in exercise.
- (b) Multiple independent variables and a single dependent variable: these studies included multiple smoking cessation elements one of which was exercise. In these studies the specific effects of exercise on smoking abstinence were not addressed.
- (c) Single independent variable and multiple dependent variables: in these studies exercise was encouraged without a smoking cessation programme, and changes in various health and behavioural indices including smoking cessation were examined. None of these studies found a significant effect on smoking abstinence for the active condition. However, as these studies did not record the number of smokers who were trying to stop, it is difficult to evaluate their success.
- (d) Acute studies: These experimental studies assessed the acute impact of an exercise intervention on withdrawal symptoms and desire to smoke (see [Appendix 1](#)), mostly following temporary abstinence. The findings of these studies are summarised at the

end of the discussion.

- (e) Did not meet other inclusion criteria: These studies either had a follow up of less than six months, did not include smokers who were motivated to quit, did not include a non-exercise control group or did not have smoking abstinence as an outcome.

Risk of bias in included studies

Only seven studies described the randomization method in detail (Bize 2010; Ciccolo 2011; Marcus 1999; Marcus 2005; McKay 2008; Prapavessis 2007; Ussher 2003). The strictest measure of abstinence was continuous in five studies, prolonged abstinence in two, point prevalence in six, and was not specified in two. Post-randomization dropouts were excluded from the denominator in six studies (Bize 2010; Ciccolo 2011; Hill 1993; Kinnunen 2008; Prapavessis 2007; Taylor 1988). Eight studies stated that those lost to follow up were counted as having relapsed to smoking (Bize 2010; Ciccolo 2011; Hill 1985; Marcus 1991; Marcus 1999; Marcus 2005; McKay 2008; Ussher 2003).

Effects of interventions

We defined the efficacy of the intervention in terms of the risk ratio (RR) for quitting in the treatment group versus the controls. Three studies showed significantly higher abstinence rates in a physically active group versus a control group at end of treatment (Marcus 1991; Marcus 1999; Martin 1997). One of these studies also showed a benefit for exercise versus control on abstinence at the three-month follow up and a benefit for exercise of borderline significance at the 12-month follow-up point (Marcus 1999). The latter study showed a difference in abstinence rates for the exercise condition compared with the control of 11.9% versus 5.4% ($p = 0.05$, RR 2.19, 95% confidence interval (CI), 0.97 to 4.96) at the 12-month follow up. One study showed significantly higher abstinence rates for the exercise group versus a control group at the three-month follow up but not at the end of treatment or 12-month follow up (Marcus 2005). The latter study also found that those with higher levels of exercise adherence were significantly more likely to achieve smoking abstinence at the end of treatment. The other studies showed no significant effect for exercise on abstinence. Several of the studies showed a trend for higher rates of abstinence in the exercise condition compared with the controls (Ciccolo 2011; Hill 1985; Kinnunen 2008; Marcus 1995; Prapavessis 2007). Only six studies had a sufficiently large sample size to have a good prospect of detecting a significant difference between the treatment and control conditions (Bize 2010; Marcus 1999; Marcus 2005; Martin 1997; McKay 2008; Ussher 2003). One of the studies did not provide separate abstinence data for the experimental and control groups, although it was reported that

no significant difference was found between the groups (Russell 1988).

In addition to comparing the exercise condition with a control group, four of the studies examined the effectiveness of exercise versus nicotine replacement therapy (NRT) (Hill 1993; Kinnunen 2008; Martin 1997; Prapavessis 2007). In one study at end of treatment and at 12-month follow up abstinence rates were significantly higher in the exercise-plus-patch group than in the exercise-only group (Prapavessis 2007). The other studies observed no significant differences.

DISCUSSION

Cessation programmes

In one study the effect of the treatment may have been compromised by the smoking cessation programme being limited to a single counselling session (Taylor 1988). This study differed from the others in that the interventions were not intended to initiate smoking abstinence but rather to maintain abstinence in smokers following acute myocardial infarction (AMI). Thus the results, which did not show any benefit for exercise, cannot easily be generalized beyond abstaining post-AMI smokers. This trial also compared the combined effect on smoking abstinence of four different exercise interventions with the combined effect of two different control interventions; therefore it was not possible to relate outcomes for smoking cessation to specific interventions. This study is further limited by providing smoking cessation counselling for only one of the two control conditions.

The results of one of the studies, showing a positive effect for exercise on smoking abstinence at end of treatment, may have been confounded by the exercise group receiving a different cessation programme than the control group (Martin 1997). In four of the studies the exercise condition received more staff contact time than the control (Hill 1985; Marcus 1991; Martin 1997; Taylor 1988), leading to the question of whether the outcomes for abstinence were due to exercise alone or due to additional social support.

It has been recommended that a smoking cessation programme should start before the quit date and continue into the period of abstinence (Raw 1998). Yet only seven of the trials did this (Bize 2010; Hill 1993; Kinnunen 2008; Marcus 1999; Marcus 2005; Prapavessis 2007; Ussher 2003). With the provision of more extensive cessation programmes the impact of the interventions may have been more pronounced. Furthermore, only one of the studies (Ussher 2003) described an intervention in which the smoking cessation and exercise components were integrated in such a way as to reinforce exercise as a coping strategy for smoking cessation (Marlatt 1985; Taylor 2010). For example, the potential for exercise to be used to reduce cigarette cravings and withdrawal

symptoms (Taylor 2007b) was not made explicit in the majority of studies.

Target populations

Demographic factors, such as age, gender, weight, fitness level, socio-economic status and occupation could influence outcomes for both smoking cessation (Jarvis 1997; Vangeli 2011) and exercise behaviour (Caspersen 1994; Pate 1995). Of the six trials which recruited men and women, two compared outcomes by gender (Hill 1993; Ussher 2003), and no differences were reported. None of the studies considered outcomes relative to occupation, socio-economic status or age. It is possible that the relationship between demographic variables and outcomes was not explored in some of the studies because of small sample sizes. All but three of the studies were North American. Seven studies recorded ethnic status, and all reported a predominantly white sample (Ciccolo 2011; Kinnunen 2008; Marcus 1999; Marcus 2005; Martin 1997; McKay 2008; Ussher 2003). Researchers must consider whether these results can be generalized to other national and ethnic populations (Caspersen 1994; King 1997; Mackay 1996). One trial recruited post-acute myocardial infarction (AMI) patients, while the remaining trials recruited from the general population of smokers. Trials are needed among other populations of smokers who might especially benefit from an exercise intervention. Given the high prevalence of smoking among people with mental illness, and the established benefits of regular physical activity for mental health (Stathopoulou 2006), research is needed to examine the role that physical activity may play as an aid to quitting. Those with serious mental illness are likely to be receptive to exercise as an aid to cessation (Arbour-Nicitopoulos 2011; Arbour-Nicitopoulos 2011b; Faulkner 2007) and an exercise intervention has been successfully piloted among women smokers with depression (Vickers 2009). One excluded study showed that teenage smokers are likely to benefit from an exercise intervention (Horn 2011), although this study was limited by including individuals with various levels of motivation for quitting. Further trials with teenagers who are motivated to quit are warranted. Obese quitters may have a particular need for weight control interventions, such as exercise (Lycett 2011), and we have yet to see a trial of exercise focusing on this population. Additionally, a non-pharmaceutical intervention such as exercise is likely to appeal to pregnant smokers (Ussher 2004; Ussher 2007) and an ongoing trial is assessing the effects of an exercise intervention in this population (Ussher 2008; Ussher 2011). Five of the studies did not present the participants' level of exercise at baseline (Ciccolo 2011; Hill 1985; McKay 2008; Russell 1988; Taylor 1988). All the remaining studies reported that they had recruited fairly sedentary smokers. A substantial proportion of smokers may be physically active (deRuiter 2008; Emmons 1994; Prochaska 1992; Ward 2003; Scioli 2009) and there is some evidence that regular exercisers may be more successful at quitting (Derby 1994; Paavola 2001; Sedgwick 1988; Abrantes 2009), yet

it is not clear whether exercise interventions are effective as an aid to smoking cessation for a more active population.

Weight gain

One trial reported a significantly smaller weight gain for those in the exercise condition compared with the controls at the end of treatment (Marcus 1999). However, in this study those in the exercise condition weighed more than the controls at baseline, and this difference was not controlled for in the analysis, which makes interpretation of the finding problematic. Marcus 1999 did not find any significant differences in weight change between the treatment conditions at the three-month or 12-month follow ups. Prapavessis 2007 observed no difference in weight gain at end of treatment when comparing cognitive-behavioural support plus nicotine patches with exercise plus nicotine patches. However, Prapavessis showed that at end of treatment those in the exercise only condition gained significantly less weight than those receiving only cognitive-behavioural support. Other studies found no difference in weight gain for the exercise versus controls at end of treatment (Marcus 1991; Marcus 1995; Marcus 2005; Ussher 2003), at three- and six-month follow ups (Ciccolo 2011) or at 12 months post-cessation (Bize 2010; Ussher 2003). The studies by Ciccolo 2011, Marcus 1991 and Marcus 1995 were too small to have a realistic chance of detecting significant differences. The other studies (Bize 2010; Marcus 2005; Ussher 2003) included nicotine replacement therapy (NRT) and post-cessation weight gain is likely to be less pronounced when using NRT (Jorenby 1996). Therefore, the potential for exercise to moderate weight gain was reduced. It is possible that exercise provides a role in weight management once an individual has stopped using NRT, but this has yet to be determined.

When pooling the studies Parsons 2009 found no evidence for exercise moderating weight gain at end of treatment, but reported a benefit at 12 months follow up when combining three studies (Bize 2010; Marcus 1999; Ussher 2003). An earlier publication conducted a meta-analysis with 10 studies of weight management interventions during smoking cessation, including five of the studies included in the current review (Marcus 1991; Marcus 1995; Marcus 1999; Marcus 2005; Ussher 2003), and observed a significant benefit for the intervention in the short-term (< three months), but not in the long-term (> six months) (Spring 2009).

Nicotine replacement therapy

Prapavessis 2007 provides some indication that combining nicotine patches and exercise enhances abstinence compared with exercise alone, as would be expected given the established efficacy of NRT (Stead 2008). Future studies need to establish whether exercise offers additional benefits to those provided by NRT alone.

It is feasible that exercise could address psychosocial and physical needs that are not currently met by NRT-based programmes.

Exercise Programming

For those beginning exercise either on or after the quit date (Ciccolo 2011; Hill 1985; Martin 1997; Russell 1988) success rates may have been hampered by the demand to cope simultaneously with two major changes in health behaviour (Emmons 1994; King 1996; Patten 2001). In studies where the exercise programme started after a period of smoking abstinence the potential for exercise to moderate withdrawal symptoms during this period was lost (Taylor 2007b). In practice, when the exercise programme begins may depend on individual capabilities and preferences (Everson-Hock 2010b).

In the two studies with exercise programmes lasting for less than six weeks (Hill 1985; Martin 1997) the intervention may have been of insufficient length to encourage long-term exercise adherence. Most of the trials employed supervised, group-based exercise supplemented by a home-based programme. Where home programmes were not provided (Ciccolo 2011; Marcus 1991; Marcus 1995; Marcus 1999) it is possible that the participants' high level of dependence on supervised exercise reduced their level of post-intervention activity.

Those adequately powered trials not showing a consistent effect of exercise on smoking abstinence (Bize 2010; Marcus 2005; McKay 2008; Ussher 2003) had interventions of a low intensity, in that they promoted moderate intensity rather than vigorous intensity exercise. In one case they relied solely on fairly brief exercise counselling (Ussher 2003), in two other studies supervised exercise was only provided once per week (Bize 2010; Marcus 2005) and the remaining study relied on a web-based programme (McKay 2008). In these studies the exercise intervention may have been insufficiently intense to benefit smoking abstinence. Further studies are required to establish the optimum intensity of exercise intervention required as an aid to smoking cessation. Intensity here refers to both the exercise intensity per se (i.e. light, moderate or vigorous) and the extensiveness of the support providing (e.g. number of supervised exercise sessions). The findings from Marcus 2005 suggest that abstaining smokers may need to accumulate at least 110 minutes of activity per week to maintain abstinence (at least during the intervention period), and supervised exercise on two or three days a week may be necessary to achieve this. A recent pilot study showed promising findings for an intervention involving moderate intensity exercise supervised on three days a week over eight weeks (Williams 2010) and this needs to be tested in a larger trial.

Only two of the studies provided any post-intervention exercise programming (Hill 1993; Ussher 2003), and this may have reduced post-intervention exercise adherence (King 1989). However, it is not possible to draw any conclusions about whether various aspects of the intervention affected levels of exercise adherence

after the formal supervised programme ended because none of the studies reported rates of adherence for this period.

One study promoted resistance exercise (Ciccolo 2011) and the remaining studies focussed on cardiovascular-type exercise. More studies are required with non-cardiovascular exercise. For example, isometric exercise has been shown to reduce tobacco cravings and urges to smoke (Ussher 2006; Ussher 2009), and has been successfully piloted (Al-Chalabi 2008). Also, yoga has been found to reduce cravings for tobacco (Elibero in press) and an ongoing study is assessing a yoga intervention as a smoking cessation aid (Bock 2010).

Exercise Adherence Issues

During the treatment period a range of cognitive-behavioural methods were employed to improve adherence to the exercise programme. All but four of the studies used group-based exercise (Ciccolo 2011, Kinnunen 2008, McKay 2008; Ussher 2003). Only three studies did not provide full supervision of facility-based exercise (Kinnunen 2008, McKay 2008; Ussher 2003). All the studies included goal setting; five used self-monitoring (Hill 1985; Kinnunen 2008; Martin 1997; Russell 1988; Taylor 1988); one used reinforcement (Martin 1997); one used telephone follow up in the case of non-attendance (Hill 1993); and one used remote monitoring of heart rate (Taylor 1988). One study employed exercise counselling, including a broad range of cognitive-behavioural techniques (Ussher 2003). Three studies did not report overall activity levels for the treatment group during the treatment period (Ciccolo 2011; Hill 1993; McKay 2008). Where supervised exercise was offered attendance at these sessions was high. Where the emphasis was on home-based exercise (Bize 2010; Marcus 2005; McKay 2008; Ussher 2003) only a minority of the participants achieved the criterion level of exercise. For example, in one study combining home-based exercise with one supervised session of exercise per week, 50% of those in the exercise group were still classed as sedentary at the end of treatment (Bize 2010). One study reported greater attrition for the exercise group compared with the controls (Marcus 1999 - see Borrelli 2002). Another study reported lower attendance for the exercise intervention compared with the health education programme (Kinnunen 2008). The one Internet-based trial observed very similar levels of physical activity for the two groups at the six-month follow up (McKay 2008). Future studies need to consider other methods for increasing 'home-based' physical activity. For example, pedometers have been used to increase participation in a walking-based intervention during smoking cessation (Prochaska 2008).

Fitness measures

Although many of the studies reported fitness measures for the control group during the treatment period (Ciccolo 2011; Hill

1985; Kinnunen 2008; Marcus 1991; Marcus 1995; Marcus 1999; Prapavessis 2007; Russell 1988; Taylor 1988) only four of the investigations reported physical activity (PA) levels for the controls at this time (Bize 2010; Hill 1985; Kinnunen 2008; Ussher 2003). Therefore in the vast majority of the studies the relative increase in PA in the treatment group versus any spontaneous increase in activity in the control group could not be accurately monitored. During the follow-up period none of the studies described using cognitive or behavioural techniques to encourage regular exercise. Only three of the studies recorded fitness measures at this time (Ciccolo 2011; Prapavessis 2007; Russell 1988) and only two studies reported levels of activity at 12-month follow up (Bize 2010; Ussher 2003). Therefore for the vast majority of studies it was not possible to relate long-term smoking abstinence to exercise behaviour.

Fitness measures are useful as a confirmation of exercise adherence. However, the significance of changes in fitness in the context of smoking cessation is debatable. Since exercise has been shown to benefit psychological and general health without increases in fitness (Taylor 2008; Pate 1995) it is possible that exercise could aid smoking cessation independently of any changes in physical capacity. A number of the trials reported a significant increase in fitness levels at the end of the treatment period within the active exercise condition (Marcus 1991; Marcus 1995; Marcus 1999 (see also Albrecht 1998); Marcus 2005; Prapavessis 2007). Three studies showed an increase in fitness for the intervention conditions compared with the controls at end of treatment (Marcus 1999; Prapavessis 2007; Taylor 1988); others showed no differences at end of treatment, at a four-month follow up (Kinnunen 2008; Russell 1988) or at 12-month follow up (Prapavessis 2007).

Psychological measures

The majority of the studies used psychological measures at baseline, but only seven trials reported changes in these measures (Kinnunen 2008; Marcus 1999; Marcus 2005; Martin 1997; Prapavessis 2007; Russell 1988; Ussher 2003). Russell 1988 found a significant increase in Profile of Mood States (POMS) tension-anxiety scores for the active group compared with the controls at four months follow up. These findings are not consistent with the general consensus that exercise reduces mood disturbance, stress and anxiety (Taylor 2000; Taylor 2008; Stathopoulou 2006). The reported effect on psychological outcomes may have been caused by extraneous variables which could not be controlled for with such a small sample size. Martin 1997 found no significant treatment differences on mood (POMS) or depression (Beck Depression Inventory) when comparing measures taken at baseline and seven days post-quit, although these findings may have been influenced by the sample including a large number of individuals with a history of major depression. Prapavessis 2007 showed that reports of self efficacy for stopping smoking were higher in a cognitive-behavioural support condition compared with an exercise-

only condition. [Marcus 1999](#) did not find a significant change in reports of tobacco withdrawal symptoms and cigarette cravings for exercise versus controls across the treatment period. [Kinnunen 2008](#) did not find any difference in reports of withdrawal symptoms for the exercise group versus the controls at one week post-cessation. [Bize 2010](#) found no significant differences in reports of withdrawal symptoms, depression, urges to smoke or perceived stress for the exercise group versus the control group. [Marcus 2005](#) observed that, among 40 women who were abstinent at the end of treatment, those who increased their fitness were more likely to report decreases in depressive symptoms ([Williams 2008](#)). [Ussher 2003](#) observed a reduction in some withdrawal symptoms for exercise versus controls up to three weeks post-cessation. None of the above studies looked in detail at the effect of exercise on sleep disturbance, and this may be a worthwhile objective. For example, [Grove 2006](#) observed that, compared with controls, regular participation in exercise, during the period of tobacco withdrawal, did not affect the ability to stay asleep but exercisers reported significantly less difficulty falling asleep. It would also be valuable if affective changes after exercise were assessed among different subgroups of smokers. For example, one study observed that, among women smokers with increased concern about weight gain, engagement in exercise was associated with less of an increase in negative affect following smoking cessation ([Schneider 2007](#)).

Acute effect of exercise on tobacco withdrawal and cravings

The Appendix presents a summary of 27 studies we identified which have assessed the acute effects of exercise on smoking outcomes. Two studies only used outcomes related to smoking intake ([Mikhail 1983](#); [Reeser 1983](#)). The remaining 25 studies included outcomes related to tobacco withdrawal/mood and/or tobacco cravings. Three studies assessed outcomes during an attempt to quit smoking ([Arbour-Nicitopoulos 2011](#), [Bock 1999](#); [Williams 2011](#)). Of these studies one reported a significant reduction in tobacco withdrawal symptoms and cigarette cravings for the vast majority of the exercise bouts throughout the intervention ([Bock 1999](#)). Of the other two studies involving a quit attempt, one found no effect of exercise on cravings or withdrawal symptoms ([Arbour-Nicitopoulos 2011](#)) and the other showed that exercise increased energy and reduced tiredness but had no effect on cravings ([Williams 2011](#)), compared with a passive control group. We found 22 studies that examined the acute effects of exercise on withdrawal symptoms and/or cravings among temporarily abstinent smokers and all but five of these studies ([Daley 2004](#); [Daniel 2007](#); [Everson 2006](#); [Faulkner 2010](#); [Pomerleau 1987](#)) observed a significant reduction in cravings and/or withdrawal symptoms compared with a passive control. A previous systematic review ([Taylor 2007b](#)) of 14 studies provides a more detailed discussion but this section highlights some findings from more recent studies which have shown an acute benefit of exercise during temporary

smoking abstinence. These studies showed that, compared with a passive condition, after periods of up to 17 hours without smoking, smokers have lower cravings, withdrawal symptoms and negative affect during and for up to 30 minutes post-exercise. The effects are evident for moderate and vigorous intensity exercise, for Hatha Yoga, and for durations from 5 minutes of seated isometric exercise to 20 - 30 minutes of cardiovascular activity. Encouragingly, relatively convenient forms of physical activity (e.g. 10 - 15 minutes of brisk walking) can be effective. [Haasova 2011](#) quantified the effects of a single bout of exercise on strength of desire to smoking using original data from 15 studies. The pooled estimate for treatment effect (non-standardised mean difference) was -1.908 (95% CI -2.721; -1.095), with a high degree of between-study heterogeneity. There has been a tendency for studies with shorter bouts of exercise to show a less sustained effect on reducing cravings and withdrawal and further research is needed to understand how the dose of exercise impacts on the duration of acute effects. However, even brief bouts of exercise, with a brief effect, may be useful to cope with a temporary spike in cravings. Several mechanisms have been tested among these studies for how exercise reduces cravings. Distraction ([Daniel 2006](#)) and expectancy ([Daniel 2007](#)) do not appear to explain the effects. Cortisol remained constant in a vigorous exercise condition, compared with declines in moderate and passive conditions, despite similar and significant reductions in cravings in both physically active conditions ([Scerbo 2010](#)). This suggests that cortisol changes do not mediate the effects of exercise on cravings. [Taylor 2006a](#) reported that reductions in urges to smoke in response to exercise were mediated by reductions in tension. Two studies involving functional Magnetic Resonance Imagery (fMRI) scanning suggested that parts of the brain that are typically activated by smoking cues (images) were less activated ([Janse van Rensburg 2009b](#), [Janse van Rensburg 2010](#)) following moderate intensity exercise. Finally, one study ([Janse van Rensburg 2009a](#)) reported that after exercise, compared with rest, abstinent smokers had less attentional bias (gaze or dwell time, measured using eye-tracker technology) towards smoking images, compared with neutral images presented simultaneously. Shifts in attentional bias away from smoking-related cues, after exercise, are in line with other studies in which participants report improvements in concentration (as a withdrawal symptom) after exercise (e.g. [Ussher 2001](#), [Ussher 2006](#), [Daniel 2006](#)). Further work is needed to understand how different types of exercise (e.g. isometric, resistance, cardiovascular) influence symptoms known to cause relapse among actual quitters, and among those using pharmaceutical aids to cessation, in which case symptoms may be lower at the outset. In addition to studies focusing on self-reported cravings six studies ([Reeser 1983](#); [Mikhail 1983](#); [Thayer 1993](#); [Katomeri 2007](#); [Faulkner 2010](#); [Taylor 2007a](#)) reported that a bout of exercise delayed ad libitum smoking, or favourably influenced smoking topography. Overall, given this experimental evidence further research is needed to understand how best to promote the use of acute bouts of physical activity, in con-

trast to longer scheduled bouts of exercise, as a momentary aid to smoking cessation,

Overall commentary

A comparison of the studies was complicated by differences in study design and intervention, and by the relative paucity of rigorous research in this field. There were marked variations between the studies in the length, type and timing of the exercise intervention, in the design of the control condition and cessation programme, and in the demographic factors recorded. In addition, there was a general absence of data relating to the physical activity levels of the control groups, and of either group during the follow-up period. Together, these factors restricted meaningful comparison of results between studies. The findings presented in this review have implications for future research in this field. One of the first requirements for future work must be to have trials with larger sample sizes.

It is possible that a greater integration between the smoking cessation and exercise programmes may have enhanced abstinence rates (Taylor 2010). In future research exercise could be presented more as a self-control strategy as well as a means of increasing fitness and general health and of managing body weight (Marlatt 1985). For example, in initiating abstinence, exercise could be presented as a strategy for managing withdrawal symptoms and overcoming physical dependency (Taylor 2007b). As regards relapse prevention, exercise could be presented as a strategy which increases self esteem and pride in one's health, and reinforces an identity as a non-smoker and as a physically active person (Verkooijen 2008) in such a way that being a smoker is incompatible with these perceptions (Fox 1998). Critically, it is likely that exercise needs to be maintained for it to continue to aid smoking cessation. An ongoing trial is assessing the effectiveness of a home and community-based lifestyle exercise maintenance intervention in assisting women to *maintain* exercise following the termination of an exercise aided smoking cessation program, and hence reduce smoking relapse (Jung 2010; Fitzgeorge 2011).

At what point should the smoker who is trying to quit begin an exercise programme? In the studies reviewed, there was wide variation in the timing of the exercise programme. Some recommendations for changes in exercise and smoking behaviour are for sequential rather than simultaneous changes but this is likely to be specific to the individual's needs (Emmons 1994; King 1996; McEwen 2006; Everson 2008b). Another study showed a tendency for higher quit rates among those increasing exercise simultaneously rather than sequentially (Hyman 2007). It has been argued that a physical activity programme should begin prior to quitting, thereby allowing people to adjust to the demands of being more active before significantly changing their smoking behaviour (Marcus 1995). Elsewhere, it has been shown that abstaining smokers are more confident about adopting exercise than those preparing to quit (King 1996), which would support the

notion of beginning an exercise programme when already abstinent, although delaying the start of the programme would reduce the potential for managing withdrawal symptoms (Taylor 2007b). A quasi-experimental study has reported higher adherence rates for smokers who undergo an exercise regimen commencing eight weeks before the quit day compared with those starting exercise on the quit day (Patten 2001). Further empirical work is required in order to ascertain the relative benefits of initiating exercise at different points in the cessation schedule. In addition, studies included in the current review focus on individuals who are motivated to quit smoking. A recent study recruited teenage smokers at different stages of motivation for quitting (Horn 2011), although the data was not analysed according to level of motivation to quit. Studies are needed to determine whether exercise can be used to increase quit attempts among those who are not motivated to initiate such an attempt and this issue is being explored in an ongoing study (Taylor 2011).

Only one study with balanced contact time showed a long-term effect of exercise on smoking cessation (Marcus 1999). This study combined a vigorous intensity, thrice weekly supervised exercise programme with cognitive-behavioural support. It has yet to be determined whether a less intensive exercise intervention can aid smoking cessation. Finally, there is no evidence of harm in promoting physical activity to smokers. That is, no studies report reduced smoking cessation rates in an exercise group compared with control conditions and exercise has many benefits as a harm reduction strategy for smokers (deRuiter 2006).

AUTHORS' CONCLUSIONS

Implications for practice

Only one of the 15 trials reviewed offered evidence for exercise aiding smoking cessation in the long term. The trials which did not show a significant effect of exercise on smoking abstinence were either too small to exclude reliably an effect of the intervention, had numerous methodological limitations or included an intervention which was not intense enough to produce the required changes in exercise levels. There is insufficient evidence to recommend exercise as a specific aid to smoking cessation. There is strong evidence to recommend exercise as an aid for reducing tobacco withdrawal and cravings, and further research is needed to understand how best to integrate this advice into current smoking cessation programmes.

Implications for research

Further trials are needed with larger sample sizes, sufficiently intense exercise interventions, equal contact control conditions, and measures of exercise adherence across the sample. Further work is needed to unravel the relationship between different intensities

and timings of exercise intervention, and different types of exercise, and the effect on smoking abstinence and on underlying processes such as tobacco withdrawal and cravings.

ACKNOWLEDGEMENTS

We would like to acknowledge Robert West and Andrew McEwen who contributed to earlier versions of this review.

REFERENCES

References to studies included in this review

Bize 2010 *{published data only}*

* Bize R, Willi C, Chiolerio A, Stoianov R, Payot S, Locatelli I, Cornuz J. Participation in a population-based physical activity programme as an aid for smoking cessation: a randomised trial. *Tobacco Control* 2010;**19**(6):488–94.
Cornuz J, Willi C, Chiolerio A, Payot S, Stoianov R, Bize R. Physical activity as an aid to smoking cessation: A randomized controlled trial of sedentary adults smokers. *Journal of General Internal Medicine* 2007;**22**(S1):107.

Ciccolo 2011 *{published data only}*

Ciccolo JT, Dunsiger SI, Williams DM, Bartholomew JB, Jennings EG, Ussher MH. Resistance Training as an Aid to Standard Smoking Cessation Treatment: A Pilot Study. *Nicotine & Tobacco Research* 2011;**13**(8):756–60.

Hill 1985 *{published data only}*

Hill JS. Effect of a program of aerobic exercise on the smoking behaviour of a group of adult volunteers. *Canadian Journal of Public Health* 1985;**76**:183–6.

Hill 1993 *{published data only}*

Hill RD, Rigdon M, Johnson S. Behavioural smoking cessation treatment for older chronic smokers. *Behavioural Therapy* 1993;**24**:321–9.

Kinnunen 2008 *{published data only}*

* Kinnunen T, Leeman RF, Korhonen T, Quiles ZN, Terwal DM, Garvey AJ, et al. Exercise as an adjunct to nicotine gum in treating tobacco dependence among women. *Nicotine & Tobacco Research* 2008;**10**:689–703.
Korhonen T, Goodwin A, Miesmaa P, Dupuis EA, Kinnunen T. Smoking cessation program with exercise improves cardiovascular disease biomarkers in sedentary women. *Journal of Womens Health* 2011;**20**:1051–64.
Korhonen T, Kinnunen T, Quiles Z, Leeman RF, Terwal DM, Garvey AJ. Cardiovascular risk behavior among sedentary female smokers and smoking cessation outcomes. *Tobacco Induced Disease* 2005;**3**:7–26.
Mustonen T. Aerobic exercise as a behavioral adjunct to nicotine replacement therapy among female smokers.

Society for Research on Nicotine and Tobacco 11th Annual Meeting. Prague, Czech Republic. 20–23 March. 2005.
Quiles ZN, Leeman RF, Molinelli L, Nordstrom BL, Garvey AJ, Hartley LH, et al. Exercise as a behavioral adjunct to nicotine gum for smoking cessation - preliminary findings (PO2 42). Society for Research on Nicotine and Tobacco 8th Annual Meeting February 20–23, 2002, Savannah, Georgia. 2002:59.

Marcus 1991 *{published data only}*

Marcus BH, Albrecht AE, Niaura RS, Abrams DB, Thompson PD. Usefulness of physical exercise for maintaining smoking cessation in women. *American Journal of Cardiology* 1991;**68**:406–7.

Marcus 1995 *{published data only}*

Marcus BH, Albrecht AE, Niaura RS, Taylor ER, Simkin LR, Feder SI, et al. Exercise enhances the maintenance of smoking cessation in women. *Addictive Behaviors* 1995;**20**: 87–92.

Marcus 1999 *{published data only}*

Albrecht AE, Marcus BH, Roberts M, Forman DE, Parisi AF. Effect of smoking cessation on exercise performance in female smokers participating in exercise training. *American Journal of Cardiology* 1998;**82**:950–5.
Bock BC, Marcus BH, King TK, Borrelli B, Roberts MR. Exercise effects on withdrawal and mood among women attempting smoking cessation. *Addictive Behaviors* 1999;**24**:399–410.
Borrelli B, Hogan JW, Bock B, Pinto B, Roberts M, Marcus B. Predictors of quitting and dropout among women in a clinic-based smoking cessation program. *Psychology of Addictive Behaviors* 2002;**16**:22–7.
* Marcus BH, Albrecht AE, King TK, Parisi AF, Pinto BM, Roberts M, et al. The efficacy of exercise as an aid for smoking cessation in women: a randomised controlled trial. *Archives of Internal Medicine* 1999;**159**:1229–34.
Marcus BH, King TK, Albrecht AE, Parisi AF, Abrams DB. Rationale, design, and baseline data for Commit to Quit: An exercise efficacy trial for smoking cessation among women. *Preventive Medicine* 1997;**26**:586–97.

Marcus 2005 *{published data only}*

Albrecht AE, Parisi AF, Roberts M, Marcus BH. Exercise

- and smoking quit rates in women: Moderate versus vigorous exercise. 2004; 36 (5):S231.. *Medicine and Science in Sports and Exercise* 2004;**36**(5 Suppl):S231.
- Marcus B, Lewis B, Hogan J, King T, Albrecht RN, Bock B, et al. The efficacy of moderate intensity physical activity for smoking cessation among women. Annual Meeting of the Society of Behavioral Medicine, Salt Lake City, USA. 2003.
- * Marcus BH, Lewis BA, Hogan J, King TK, Albrecht AE, Bock B, et al. The efficacy of moderate-intensity exercise as an aid for smoking cessation in women: a randomized controlled trial. *Nicotine & Tobacco Research* 2005;**7**: 871–80.
- Marcus BH, Lewis BA, King TK, Albrecht AE, Hogan J, Bock B, et al. Rationale, design, and baseline data for Commit to Quit II: an evaluation of the efficacy of moderate-intensity physical activity as an aid to smoking cessation in women. *Preventive Medicine* 2003;**36**:479–92.
- Martin 1997 {published data only}**
- * Martin JE, Kalfas KJ, Patten CA. Prospective evaluation of three smoking interventions in 205 recovering alcoholics: one-year results of project SCRAP-Tobacco. *Journal of Consulting and Clinical Psychology* 1997;**65**:190–4.
- Patten CA, Martin JE, Calfas KJ, Brown SA, Schroeder DR. Effect of three smoking cessation treatments on nicotine withdrawal in 141 abstinent alcoholic smokers. *Addictive Behaviors* 2000;**25**:301–6.
- Patten CA, Martin JE, Calfas KJ, Lento J, Wolter TD. Behavioral treatment for smokers with a history of alcoholism: predictors of successful outcome. *Journal of Consulting and Clinical Psychology* 2001;**69**:796–801.
- Patten CA, Vickers KS, Martin JE, Williams CD. Exercise interventions for smokers with a history of alcoholism: Exercise adherence rates and effect of depression on adherence. *Addictive Behaviors* 2001;**27**:1–11.
- McKay 2008 {published data only}**
- McKay HG, Danaher BG, Seeley JR, Lichtenstein E, Gau JM. Comparing two web-based smoking cessation programs: randomized controlled trial. *Journal of Medical Internet Research* 2008;**10**(5):e40.
- Prapavessis 2007 {published data only}**
- Hammett CJ, Prapavessis H, Baldi JC, Varo N, Schoenbeck U, Ameratunga R, et al. Effects of exercise training on 5 inflammatory markers associated with cardiovascular risk. *American Heart Journal* 2006;**151**:367.e7–367.e17.
- Prapavessis H. The effects of exercise and nicotine replacement therapy on smoking rates in women. Eighth International Congress of Behavioural Medicine, Mainz, Germany. 2004.
- * Prapavessis H, Cameron L, Baldi JC, Robinson S, Borrie K, Harper T, et al. The effects of exercise and nicotine replacement therapy on smoking rates in women. *Addictive Behaviors* 2007;**32**:1416–32.
- Russell 1988 {published data only}**
- Russell PO, Epstein LH, Johnson JJ, Block DR, Blair E. The effects of exercise as maintenance for smoking cessation. *Addictive Behaviors* 1988;**13**:215–8.
- Taylor 1988 {published data only}**
- Taylor CB, Houston-Miller N, Haskell WL, Debusk RF. Smoking cessation after acute myocardial infarction: The effects of exercise training. *Addictive Behaviors* 1988;**13**: 331–4.
- Ussher 2003 {published data only}**
- * Ussher M, West R, McEwen A, Taylor A, Steptoe A. Efficacy of exercise counselling as an aid for smoking cessation: a randomized controlled trial. *Addiction* 2003; **98**:523–32.
- Ussher M, West R, McEwen A, Taylor A, Steptoe A. Efficacy of exercise counselling as an aid to smoking cessation: A randomised controlled trial. European Conference of the Society for Research on Nicotine and Tobacco. 2001.
- Ussher, M, West, W, McEwen, A, Taylor, AH, & Steptoe, A. Randomized controlled trial of physical activity counseling as an aid to smoking cessation: 12 month follow-up. *Addictive Behaviors* 2007;**32**:3060–4.
- References to studies excluded from this review**
- Al-Chalabi 2008 {published data only}**
- Al-Chalabi L, Prasad N, Steed L, Stenner S, Aveyard P, Beach J, Ussher M. A pilot randomised controlled trial of the feasibility of using body scan and isometric exercises for reducing urge to smoke in a smoking cessation clinic. *BMC Public Health* 2008;**8**:349.
- Arbour-Nicitopoulos 2011 {published data only}**
- Arbour-Nicitopoulos K, Faulkner GE, Hsin A, Selby P. A pilot study examining the acute effects of exercise on craving reduction and affect among individuals with serious mental illness. *Mental Health & Physical Activity* In Press.
- Caliani 2004 {published data only}**
- Caliani SE, Navas JCB, Gomez-Doblas JJ, Rivera RC, Jimenez BG, Lao MM, et al. Postmyocardial infarction cardiac rehabilitation in low risk patients. Results with a coordinated program of cardiological and primary care.. *Revista Espanola de Cardiologia* 2004;**57**:53–9.
- Chaney 2008 {published data only}**
- Chaney SE, Sheriff S. Weight gain among women during smoking cessation: testing the effects of a multifaceted program. *American Association of Occupational Health Nurses Journal* 2008;**56**:99–105.
- Cinciripini 1996 {published data only}**
- Cinciripini PM, Cinciripini LG, Wallfisch A, Haque W, Van Vunakis H. Behavior therapy and the transdermal nicotine patch: effects on cessation outcome, affect, and coping. *Journal of Consulting and Clinical Psychology* 1996; **64**:314–23.
- Clark 2005 {published data only}**
- Clark MM, Hays JT, Vickers KS, Patten CA, Croghan IT, Berg E, et al. Body image treatment for weight concerned smokers: A pilot study. *Addictive Behaviors* 2005;**30**: 1236–40.
- Copeland 2006 {published data only}**
- Copeland AL, Martin PD, Geiselman PJ, Rash CJ, Kendzor DE. Smoking cessation for weight-concerned women:

- group vs. individually tailored, dietary, and weight-control follow-up sessions. *Addictive Behaviors* 2006;**31**:115–27.
- Daley 2004** *{published data only}*
Daley AJ, Oldham ARH, Townson M. The effects of acute exercise on affective responses and desire to smoke in sedentary temporarily abstaining smokers: a preliminary study. *Journal of Sports Sciences* 2004;**22**:303–4.
- Daniel 2004** *{published data only}*
Daniel JZ, Cropley M, Ussher M, West R. Acute effects of a short bout of moderate versus light intensity exercise versus inactivity on tobacco withdrawal symptoms in sedentary smokers. *Psychopharmacology* 2004;**174**:320–6.
- Daniel 2006** *{published data only}*
Daniel JZ, Cropley M, Fife-Schaw C. The effect of exercise in reducing desire to smoke and cigarette withdrawal symptoms is not caused by distraction. *Addiction* 2006;**101**: 1187–92.
- Daniel 2007** *{published data only}*
Daniel JZ, Cropley M, Fife-Schaw C. Acute exercise effects on smoking withdrawal symptoms and desire to smoke are not related to expectation. *Psychopharmacology* 2007;**195**: 125–9.
- Elibero in press** *{published data only}*
Elibero A, Janse Van Rensburg K, Drobos D. Acute effects of aerobic exercise and hatha yoga on craving to smoke. *Nicotine & Tobacco Research* in press.
- Everson 2006** *{published data only}*
Everson ES, Daley AJ, Ussher M. Does exercise have an acute effect on desire to smoke, mood and withdrawal symptoms in abstaining adolescent smokers. *Addictive Behaviors* 2006;**31**:1547–58.
- Everson 2008a** *{published data only}*
Everson ES, Daley AJ, Ussher M. Moderate and vigorous intensity exercise acutely reduce cravings and withdrawal symptoms in abstaining young adult smokers. *Mental Health and Physical Activity* 2008;**1**:26–31.
- Faulkner 2010** *{published data only}*
Faulkner G, Arbour-Nicitopoulos K, Hsin A. Cutting down one puff at a time: The acute effects of exercise on smoking behaviour. *Journal of Smoking Behavior* 2010;**5**:130–5.
- Fortmann 1995** *{published data only}*
Fortmann SP, Killen JD. Nicotine gum and self-help behavioral treatment for smoking relapse prevention: results from a trial using population-based recruitment. *Journal of Consulting and Clinical Psychology* 1995;**63**:460–8.
- Grove 1993** *{published data only}*
Grove JR, Wilkinson A, Dawson BT. Effects of exercise on selected correlates of smoking withdrawal. *International Journal of Sport Psychology* 1993;**24**:217–36.
- Grove 2006** *{published data only}*
Grove JR, Wilkinson A, Dawson BT, Eastwood PR, Heard NP. Effects of exercise on subjective aspects of sleep during tobacco withdrawal. *Australian Psychologist* 2005;**41**: 69–76.
- Haasova 2011** *{unpublished data only}*
Haasova M, Janse Van Rensburg K, Faulkner G, Ussher MH, Warren F, Taylor AH. The acute effects of physical activity on cigarette cravings: A meta analysis with individual participant data. Paper presented at the European College of Sports Science Conference, Liverpool, 2011.
- Horn 2011** *{published data only}*
Horn K, Dino G, Branstetter S, Zhang J, Noerachmanto N, Jarrett T, Taylor M. The effects of physical activity on teen smoking cessation. *Pediatrics* 2011;**128**(4):e801–11.
- Hurt 1992** *{published data only}*
Hurt RD, Dale LC, Offord KP, Bruce BK, McClain FL, Eberman KM. Inpatient treatment of severe nicotine dependence. *Mayo Clinic Proceedings* 1992;**67**:823–8.
- Hurt 1994** *{published data only}*
Hurt RD, Eberman KM, Croghan IT, Offord KP, Davis LJ Jr, Morse RM, et al. Nicotine dependence treatment during inpatient treatment for other addictions: a prospective intervention trial. *Alcoholism, Clinical and Experimental Research* 1994;**18**:867–72.
- Hwang 2010** *{published data only}*
Hwang GS, Jung HS, Yi Y, Yoon C, Choi JW. Smoking cessation intervention using stepwise exercise incentives for male workers in the workplace. *Asia Pacific Journal of Public Health* 2010;epub ahead of print.
- Janse van Rensburg 2008** *{published data only}*
Janse van Rensburg K, Taylor AH. The effects of acute exercise on cognitive functioning and cigarette cravings during temporary abstinence from smoking. *Human Psychopharmacology: Clinical and Experimental* 2008;**23**: 193–9.
- Janse van Rensburg 2009a** *{published data only}*
Janse Van Rensburg K, Taylor AH, Hodgson T. The effects of acute exercise on attentional bias towards smoking-related stimuli during temporary abstinence from smoking. *Addiction* 2009;**104**:1910–17.
- Janse van Rensburg 2009b** *{published data only}*
Janse Van Rensburg K, Taylor A, Hodgson T, Benattayallah A. Acute exercise modulates cigarette cravings and brain activation in response to smoking-related images: an fMRI study. *Psychopharmacology* 2009;**203**(3):589–98.
Janse van Rensburg K, Taylor AH, Hodgson T. The effects of exercise on regional brain activation in response to smoking cues during temporary abstinence from smoking. 12th European Congress of Sport Psychology, Halkidiki, Greece, 4–9 September. 2007.
- Janse van Rensburg 2010** *{unpublished data only}*
Janse van Rensburg, K. The effects of exercise on neuropsychological processes associated with a desire to smoke nicotine and cue-elicited cravings.. PhD Dissertation, University of Exeter, UK 2010.
- Jones 2001** *{published data only}*
Jones C, Griffiths RD, Skirrow P, Humphris G. Smoking cessation through comprehensive critical care. *Intensive Care Medicine* 2001;**27**(9):1547–9.

Jonsdottir 2001 {published data only}

Jonsdottir D, Jonsdottir H. Does physical exercise in addition to a multicomponent smoking cessation program increase abstinence rate and suppress weight gain? An intervention study. *Scandinavian Journal of the Caring Sciences* 2001;**15**:275–82.

Leclarungrayub 2010 {published data only}

Leclarungrayub D, Pratanaphon S, Pothongsunon P, Sriboonreung T, Yankai A, Bloomer RJ. Vernonia cinerea Less. supplementation and strenuous exercise reduce smoking rate: relation to oxidative stress status and beta-endorphin release in active smokers. *Journal of the International Society of Sports Nutrition* 2010;**7**:21.

McClure 2009 {published data only}

McClure JB, Ludman EJ, Grothaus L, Pabiniak C, Richards J. Impact of a Brief Motivational Smoking Cessation Intervention. The Get PHIT Randomized Controlled Trial. *American Journal of Preventive Medicine* 2009;**37**(2): 116–23.

McClure 2011 {published data only}

McClure JB, Catz SL, Ludman EJ, Richards J, Riggs K, Grothaus L. Feasibility and acceptability of a multiple risk factor intervention: the Step Up randomized pilot trial. *BMC Public Health* 2011;**11**:167.

McIver 2004 {published data only}

McIver S, O'Halloran P, McGartland M. The impact of Hatha yoga on smoking behavior. *Alternative Therapy Health & Medicine* 2004;**10**:22–3.

Mikhail 1983 {published data only}

Mikhail C. The acute effects of aerobic exercise on cigarette smoking. Masters Thesis, University of Lethbridge, Canada. 1983.

Oenema 2008 {published data only}

Oenema A, Brug J, Dijkstra A, de Weerd I, de Vries H. Efficacy and use of an internet-delivered computer-tailored lifestyle intervention, targeting saturated fat intake, physical activity and smoking cessation: a randomized controlled trial.. *Annals of Behavioral Medicine* 2008;**35**:125–35.

Ortega Sanchez-P 2006 {published data only}

Ortega Sanchez-Pinilla R, Aquilar-Blanco EM. Running and its influence on smoking habits. *Atencion Primaria* 2006;**37**:478–81.

Pomerleau 1987 {published data only}

Pomerleau OF, Scherzer HH, Grunberg NE, Pomerleau CS, Judge J, Fetig JB, et al. The effects of acute exercise on subsequent cigarette smoking. *Journal of Behavioral Medicine* 1987;**10**:117–27.

Prochaska 2008 {published data only}

Prochaska JJ, Hall SM, Humfleet G, Munoz RF, Reus V, Goerecki J, et al. Physical activity as a strategy for maintaining tobacco abstinence: a randomized controlled trial. *Preventive Medicine* 2008;**47**:215–20.

Ramsay 2004 {published data only}

Ramsay J, Hoffmann A. Smoking cessation and relapse prevention among undergraduate students: a pilot

demonstration project. *Journal of the American College of Health*. 2004;**53**:11–18.

Reeser 1983 {published data only}

Reeser KA. The effects of repeated aerobic and non-aerobic exercise on cigarette smoking. Masters Thesis, University of Alberta, Canada. 1983.

Scerbo 2010 {published data only}

Scerbo F, Faulkner G, Taylor A, Thomas S. Effects of exercise on cravings to smoke: the role of exercise intensity and cortisol. *Journal of Sports Sciences* 2010;**28**(1):11–9.
Scerbo, F. The impact of acute vigorous physical activity on cravings, affect, and cortisol concentration among abstinent smokers experiencing withdrawal. Master's thesis, University of Toronto, Canada 2007.

Spring 2004 {published data only}

Schneider KL, Spring B, Pagoto SL. Affective benefits of exercise while quitting smoking: influence of smoking-specific weight concern. *Psychology of Addictive Behaviors* 2007;**21**:255–60.

* Spring B, Doran N, Pagoto S, Schneider K, Pingitore R, Hedeker D. Randomized controlled trial for behavioral smoking and weight control treatment: effect of concurrent versus sequential intervention. *Journal of Consulting and Clinical Psychology* 2004;**72**:785–96.

Taylor 2005 {published data only}

Taylor AH, Katomeri M, Ussher M. Acute effects of self-paced walking on urges to smoke during temporary smoking abstinence. *Psychopharmacology* 2005;**181**:1–7.

Taylor 2006a {published data only}

Taylor AH, Katomeri M, Ussher M. Effects of walking on cigarette cravings and affect in the context of Nesbitt's paradox and the circumplex model. *Journal of Sport & Exercise Psychology* 2006;**28**:18–31.

Taylor 2006b {published data only}

Taylor AH, Katomeri M. Effects of a brisk walk on blood pressure responses to the Stroop, a speech task and a smoking cue among temporarily abstinent smokers. *Psychopharmacology* 2006;**184**:247–53.

Thayer 1993 {published data only}

Thayer R, Peters D, Takahashi P, Birkhead-Flight A. Mood and behaviour (smoking and sugar snacking) following moderate exercise: A partial test of self-regulation theory. *Personality and Individual Differences* 1993;**14**:97–104.

Ussher 2001 {published data only}

Ussher M, Nunziata P, Cropley M, West R. Effect of a short bout of exercise on tobacco withdrawal symptoms and desire to smoke. *Psychopharmacology* 2001;**158**:66–72.

Ussher 2006 {published data only}

Ussher M, Doshi R, Sampuran AK, West R. Acute effect of isometric exercise on desire to smoke and tobacco withdrawal symptoms. *Human Psychopharmacology: Clinical & Experimental* 2006;**21**:39–46.

Ussher 2008 {published data only}

Ussher M, Aveyard P, Coleman T, Straus L, West R, Marcus Bal. Physical activity as an aid to smoking cessation during

pregnancy: two feasibility studies. *BMC Public Health* 2008;**8**:328.

Ussher 2009 {published data only}

Ussher M, Cropley M, Playle S, Mohidin R, West R. Effect of isometric exercise and body scanning on cigarette cravings and withdrawal symptoms. *Addiction* 2009;**104**(7):1251–7.

Vander Weg 2008 {published data only}

Vander Weg MW, Klesges RC, Ebbert JO, Lichty EJ, Debon M, North F, et al. Trial design: blood pressure control and weight gain prevention in prehypertensive and hypertensive smokers: the treatment and prevention study. *Contemporary Clinical Trials* 2008;**29**(2):281–92.

Vickers 2005 {published data only}

Vickers KS, Patten CA, Clark MM, Ebbert JO, Croghan IT, Hathaway JC. Exercise intervention for women with depressive symptoms interested in smoking cessation. Society for Research on Nicotine and Tobacco 11th Annual Meeting, Prague, Czech Republic. 2005.

Vickers 2009 {published data only}

Vickers KS, Patten CA, Lewis BA, Clark MM, Ussher M, Ebbert JOal. Feasibility of an exercise counseling intervention for depressed women smokers. *Nicotine & Tobacco Research* 2009;**11**(8):985–95.

Whiteley 2007 {published data only}

Whiteley JA, Napolitano MA, Lewis BA, Williams DM, Albrecht A, Neighbors CJ, et al. Commit to Quit in the YMCAs: translating an evidence-based quit smoking program for women into a community setting. *Nicotine & Tobacco Research* 2007;**9**:1227–35.

Williams 2010 {published data only}

Williams DM, Whiteley JA, Dunsiger S, Jennings EG, Albrecht AE, Ussher MHal. Moderate intensity exercise as an adjunct to standard smoking cessation treatment for women: a pilot study. *Psychology of Addictive Behaviors* 2010;**24**(2):349–54.

Williams 2011 {published data only}

Williams DM, Dunsiger S, Whitely JA, Ussher MH, Ciccolo JT, Jennings EG. Acute effects of moderate intensity aerobic exercise on affective withdrawal symptoms and cravings among women smoker. *Addictive Behaviors* 2011;**36**:894–897.

Zwick 2006 {published data only}

Zwick RH, Mutzbacher P, Dovjak N, Heinze C, Burghuber OC, Zwick H. Exercise in addition to nicotine replacement therapy improves success rates in smoking cessation.. *Chest* 2006;**130**:145s.

References to ongoing studies

Bock 2010 {published data only}

Bock BC, Morrow KM, Becker BM, Williams DM, Tremont G, Gaskins RBal. Yoga as a complementary treatment for smoking cessation: rationale, study design and participant characteristics of the Quitting-in-Balance study. *BMC Complementary & Alternative Medicine* 2010;**10**:14.

Jung 2010 {published data only}

Jung ME, Fitzgeorge L, Prapavessis H, Faulkner G, Maddison R. The getting physical on cigarettes trial: Rationale and methods. *Mental Health and Physical Activity* 2010;**3**(1):35–44.

Maddison 2010 {published data only}

Maddison R, Roberts V, Bullen C, McRobbie H, Jiang Y, Prapavessis Hal. Design and conduct of a pragmatic randomized controlled trial to enhance smoking-cessation outcomes with exercise: The Fit2Quit study. *Mental Health and Physical Activity* 2010;**3**(2):92–101.

Ussher 2011 {unpublished data only}

Ussher M, Aveyard P, West R, Manyonda I, Lewis B, Marcus B, Taylor A, Coleman T. A pragmatic randomized controlled trial of physical activity as an aid to smoking cessation during pregnancy (LEAP Trial). unpublished protocol unpublished.

Additional references

Aaron 1995

Aaron DJ, Dearwater SR, Anderson R, Olsen T, Kriska AM, Laporte RE. Physical activity and the initiation of high-risk health behaviors in adolescents. *Medicine and Science in Sports and Exercise* 1995;**27**:1639–45.

Abrantes 2009

Abrantes AM, Strong DR, Lloyd-Richardson EE, Niaura R, Kahler CW, Brown RA. Regular exercise as a protective factor in relapse following smoking cessation treatment. *American Journal on Addictions* 2009;**18**(1):100–1.

Albrecht 1998

Albrecht AE, Marcus BH, Roberts M, Forman DE, Parisi AE. Effect of smoking cessation on exercise performance in female smokers participating in exercise training. *American Journal of Cardiology* 1998;**82**:950–5.

Allen 2004

Allen SS, Brintnell DM, Hatsukami D, Reich B. Energy intake and physical activity during short-term smoking cessation in postmenopausal women. *Addictive Behaviors* 2004;**29**:947–51.

Arbour-Nicitopoulos 2011b

Arbour-Nicitopoulos KP, Faulkner GE, Cohn TA, Selby P. Smoking cessation in women with severe mental illness: exploring the role of exercise as an adjunct treatment. *Archives of Psychiatric Nursing* 2011;**25**(1):43–52.

Ashelman 2000

Ashelman MW. *Stop Smoking Naturally*. New Canaan, Connecticut: Keats Publishing Inc, 2000.

Audrain-McGovern 2003

Audrain-McGovern J, Rodriguez D, Moss HB. Smoking progression and physical activity. *Cancer Epidemiology, Biomarkers and Prevention* 2003;**12**:1121–9.

Blair 1985

Blair SN, Jacobs DR Jr, Powell KE. Relationships between exercise or physical activity and other health behaviors. *Public Health Reports* 1985;**100**:172–80.

Bock 1999

Bock BC, Marcus BH, King TK, Borrelli B, Roberts MR. Exercise effects on withdrawal and mood among women attempting smoking cessation. *Addictive Behaviors* 1999; **24**:399–410.

Boots 1998

The Boots Company PLC. *Give up Smoking! Your guide to a brighter future without smoking*. Nottingham UK: The Boots Company PLC, 1998.

Borrelli 2002

Borrelli B, Hogan JW, Bock B, Pinto B, Roberts M, Marcus B. Predictors of quitting and dropout among women in a clinic-based smoking cessation program. *Psychology of Addictive Behaviors* 2002; **16**:22–7.

Boutelle 2000

Boutelle K N, Murray DM, Jeffery RW, Hennrikus DJ, Lando HA. Associations between exercise and health behaviors in a community sample of working adults. *Preventive Medicine* 2000; **30**:217–24.

Boyle 2000

Boyle RG, O'Connor P, Pronck N, Tan A. Health behaviors of smokers, ex-smokers, and never smokers in an HMO. *Preventive Medicine* 2000; **31**:177–82.

Cahill 2011

Cahill K, Stead LF, Lancaster T. Nicotine receptor partial agonists for smoking cessation. *Cochrane Database of Systematic Reviews* 2011, Issue 2: CD006103.. DOI: 10.1002/14651858.CD006103.pub3

Caspersen 1994

Caspersen CJ, Merritt RK, Stephens T. International exercise patterns: a methodological perspective. In: Dishman R editor(s). *Advances in Exercise Adherence*. Champaign Ill: Human Kinetics, 1994:73–110.

Clark 2004

Clark MM, Decker PA, Offord KP, Patten CA, Vickers KS, Croghan IT, et al. Weight concerns among male smokers. *Addictive Behaviors* 2004; **29**:1637–41.

Colbert 2001

Colbert LH, Hartman TJ, Malila N, Limburg PJ, Pietinen P, Virtamo J, et al. Physical activity in relation to cancer of the colon and rectum in a cohort of male smokers. *Cancer Epidemiology, Biomarkers and Prevention* 2001; **10**:265–8.

Correia 1998

Correia CJ, Simons J, Carey KB, Borsari BE. Predicting drug use: application of behavioral theories of choice. *Addictive Behaviors* 1998; **23**:705–9.

Cosgrove 2002

Cosgrove KP, Hunter RG, Carroll ME. Wheel-running attenuates intravenous cocaine self-administration in rats: sex differences. *Pharmacology, Biochemistry and Behavior* 2002; **73**:663–71.

Coulson 1997

Coulson NS, Eiser C, Eiser JR. Diet, smoking and exercise: interrelationships between adolescent health behaviours. *Child: Care, Health and Development* 1997; **23**:207–16.

Davis 1997

Davis TC, Arnold C, Nandy I, Bocchini JA, Gottlieb A, George RB, et al. Tobacco use among male high school athletes. *Journal of Adolescent Health* 1997; **21**:97–101.

Derby 1994

Derby CA, Lasater TM, Vass K, Gonzalez S, Carleton RA. Characteristics of smokers who attempt to quit and of those who recently succeeded. *American Journal of Preventive Medicine* 1994; **10**:327–34.

deRuiter 2006

deRuiter W, Faulkner G. Tobacco harm reduction strategies: the case for physical activity. *Nicotine & Tobacco Research* 2006; **8**:157–68.

deRuiter 2008

Deruiter WK, Faulkner G, Cairney J, Veldhuizen S. Characteristics of physically active smokers and implications for harm reduction. *American Journal of Public Health* 2008; **9**:925–31.

Dishman 2009

Dishman RK, & O'Connor, PJ. Lessons in exercise neurobiology: The case for endorphins. *Mental Health & Physical Activity* 2009; **2**(1):4–9.

Doherty 1995

Doherty K, Kinnunen T, Militello FS, Garvey AJ. Urges to smoke during the first month of abstinence: relationship to relapse and predictors. *Psychopharmacology* 1995; **119**: 171–8.

Doherty 1998

Doherty SC, Steptoe A, Rink E, Kendrick T, Hilton S. Readiness to change health behaviours among patients at high risk of cardiovascular disease. *Journal of Cardiovascular Risk* 1998; **5**:147–53.

Doll 2004

Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. *BMJ* 2004; **328**:1519.

Emmons 1994

Emmons KM, Marcus BH, Linnan L, Rossi JS, Abrams DB. Mechanisms in multiple risk factor interventions: Smoking, exercise, and dietary fat intake among manufacturing workers. *Preventive Medicine* 1994; **23**:481–9.

Escobedo 1993

Escobedo LG, Marcus SE, Holtzman D, Giovino GA. Sports participation, age at smoking initiation, and the risk of smoking among US high school students. *JAMA*. 1993; **269**:391–5.

Everson 2008b

Everson ES, Taylor AH, Ussher M. Promoting physical activity to aid smoking cessation: A qualitative perspective on multiple health behaviour change. British Psychological Society (Division of Health Psychology)/European Society of Health Psychology Conference, Bath. 2008.

Everson 2010

Everson ES, Taylor AH, Ussher M. Determinants of physical activity promotion by smoking cessation advisors as

- an aid for quitting: Support for the Transtheoretical Model. *Patient Education & Counseling* 2010;**78**:53–6.
- Everson-Hock 2010a**
Everson-Hock ES, Taylor AH, Ussher M. Readiness to use physical activity as a smoking cessation aid: a multiple behaviour change application of the Transtheoretical Model among quitters attending Stop Smoking Clinics. *Patient Education & Counseling* 2010;**79**(2):156–9.
- Everson-Hock 2010b**
Everson-Hock ES, Taylor AH, Ussher M, Faulkner G. A qualitative perspective on multiple health behaviour change: views of smoking cessation advisors who promote physical activity. *Journal of Smoking Cessation* 2010;**5**:7–14.
- Faulkner 2007**
Faulkner G, Taylor AH, Munro S, Selby P, Gee C. Exploring the acceptability of physical activity programming within a smoking cessation service for individuals with severe mental illness. *Patient Education and Counselling* 2007;**66**:123–6.
- Fitzgeorge 2011**
Fitzgeorge, L, Harper, T, Prapavessis, H, Faulkner, G, & Maddison, R. (2011). Physical activity and smoking cessation: preliminary findings of “the getting physical on cigarettes” trial.. Proceedings of Society of Research on Nicotine and Tobacco, Toronto. 2011.
- Fox 1998**
Fox KR. *The physical self: From motivation to well being*. Champaign Ill: Human Kinetics, 1998.
- Garber 2011**
Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise.. *Medicine and Science in Sports and Exercise* 2011; **43**:1334–59.
- Gritz 1989**
Gritz ER, Klesges RC, Meyers AW. The smoking and body weight relationship: Implications for intervention and postcessation weight control. *Annals of Behavioral Medicine* 1989;**11**:144–53.
- Haddock 2000**
Haddock CK, O’Byrne KK, Klesges RC, Talcott W, Lando H, Peterson AL. Relapse to smoking after basic military training in the U.S. Air Force. *Military Medicine* 2000;**165**: 884–8.
- Haddock 2004**
Haddock CK, Lando H, Klesges RC, Peterson AL, Scarinci IC. Modified tobacco use and lifestyle change in risk-reducing beliefs about smoking. *American Journal of Preventive Medicine* 2004;**27**:35–41.
- Hall 1989**
Hall SM, McGee R, Tunstall C, Duffy J, Benowitz N. Changes in food intake and activity after quitting smoking. *Journal of Consulting and Clinical Psychology* 1989;**57**:81–6.
- Hedblad 1997**
Hedblad B, Ogren M, Isacson SO, Janzo L. Reduced cardiovascular mortality risk in male smokers who are physically active. *Archives of Internal Medicine* 1997;**157**: 893–9.
- Helmert 1994**
Helmert U, Herman B, Shea S. Moderate and vigorous leisure-time physical activity and cardiovascular disease risk factors in West Germany, 1984-1991. *International Journal of Epidemiology* 1994;**23**:285–92.
- Hill 1981**
Hill JS. Health behaviour: The role of exercise in smoking cessation. *Canadian Association for Health, Physical Education and Recreation (CAHPER) Journal* 1981;**28**:15–8.
- Hu 2002**
Hu G, Pekkarinen H, Hanninen O, Yu Z, Guo Z, Tian H. Commuting, leisure-time physical activity, and cardiovascular risk factors in China. *Medicine and Science of Sports and Exercise* 2002;**34**:234–8.
- Hughes 2004**
Hughes JR, Keely J, Naud S. Shape of the relapse curve and long-term abstinence among untreated smokers. *Addiction* 2004;**99**:29–38.
- Hughes 2007**
Hughes JR, Stead LF, Lancaster T. Antidepressants for smoking cessation. *Cochrane Database of Systematic Reviews* 2007, Issue 1. DOI: 10.1002/14651858.CD000031.pub3
- Hyman 2007**
Hyman DJ, Pavlik VN, Taylor WC, Goodrick GK, Moye L. Simultaneous vs sequential counseling for multiple behavior change. *Archives of Internal Medicine* 2007;**167**:1152–8.
- Jarvis 1997**
Jarvis M. Patterns and predictors of smoking cessation in the general population. In: Bollinger CT, Fagerstrom KO editor(s). *The Tobacco Epidemic, Progress in Respiratory Research*. Vol. **28**, Basel: Karger, 1997:151–4.
- Jorenby 1996**
Jorenby DE, Hatsukami DK, Smith SS, Fiore MC, Allen S, Jensen J, et al. Characterization of tobacco withdrawal symptoms: transdermal nicotine reduces hunger and weight gain. *Psychopharmacology* 1996;**128**:130–8.
- Kaczynski 2008**
Kaczynski AT, Manske SR, Mannell RC, Grewal K. Smoking and physical activity: a systematic review. *American Journal of Health Behavior* 2008;**32**:93–110.
- Katomeri 2007**
Katomeri M. Acute effects of self-paced walking on smoking withdrawal and cravings. PhD Dissertation, University of Plymouth 2007.
- Kawachi 1996**
Kawachi I, Troisi RJ, Rotnitzky AG, Coakley EH, Colditz MS, Colditz MD. Can exercise minimise weight gain in women after smoking cessation?. *American Journal of Public Health* 1996;**86**:999–1004.

King 1989

King AC, Frey-Hewitt B, Dreon D, Wood P. Diet versus exercise in weight maintenance: The effects of minimal intervention strategies on long term outcomes in men. *Archives of Internal Medicine* 1989;**149**:2741–6.

King 1992

King AC, Blair SN, Bild DE, Dishman RK, Dubbert PM, Marcus BH, et al. Determinants of physical activity and interventions in adults. *Medicine and Science in Sports and Exercise* 1992;**24**:S221–36.

King 1996

King TK, Marcus BH, Pinto BM, Emmon, KM, Abrams DB. Cognitive behavioural mediators of changing multiple behaviours: Smoking and a sedentary lifestyle. *Preventive Medicine* 1996;**25**:684–91.

King 1997

King TK, Borrelli B, Black C, Pinto BM, Marcus BH. Minority women and tobacco: Implications for smoking cessation interventions. *Annals of Behavioral Medicine* 1997;**19**:301–13.

Klesges 1992

Klesges RC, Schumaker SA. Understanding the relations between smoking and body weight and their importance to smoking cessation and relapse. *Health Psychology* 1992;**11**:1–3.

Kujala 2007

Kujala UM, Kaprio J, Rose RJ. Physical activity in adolescence and smoking in young adulthood: a prospective twin cohort study. *Addiction* 2007;**102**:1151–7.

Leitzmann 2009

Leitzmann MF, Koebeck C, Abnet CC, Freedman ND, Park Y, Hollenbeck A, et al. Prospective study of physical activity and lung cancer by histologic type in current, former, and never smokers. *Am J Epidemiology* 2009;**169**:542–53.

Lycett 2011

Lycett D, Munafo M, Johnstone E, Murphy M, Aveyard P. Associations between weight change over 8 years and baseline body mass index in a cohort of continuing and quitting smokers. *Addiction* 2011;**106**:188–96.

Mackay 1996

Mackay J, Crofton J. Tobacco and the developing world. *British Medical Bulletin* 1996;**52**:206–21.

Marcus 2004

Marcus BH, Hampl JS, Fisher EB. *How to Quit Smoking without Gaining Weight*. Pocket Books: New York., 2004.

Marlatt 1985

Marlatt GA, Gordon JR. *Relapse prevention: maintenance strategies in the treatment of addictive behaviors*. New York: Guildford, 1985.

McDermot 2009

McDermot L, Dobson A, Owen N. Determinants of continuity and change over 10 years in young women's smoking. *Addiction* 2009;**104**:478–87.

McEwen 2006

McEwen A, Hajek P, McRobbie H, West R. *Manual of smoking cessation: A guide for counsellors and practitioners*. Oxford: Blackwell Publishing, 2006.

Metheny 1998

Metheny KB, Weatherman KE. Predictors of smoking cessation and maintenance. *Journal of Clinical Psychology* 1998;**54**:223–35.

Nguyen 1998

Nguyen MN, Beland F, Otis J. Is the intention to quit smoking influenced by other heart-healthy lifestyle habits in 30- to 60-year-old men?. *Addictive Behaviors* 1998;**23**:23–30.

Niaura 1998

Niaura R, Marcus B, Albrecht A, Thompson P, Abrams D. Exercise, smoking cessation, and short-term changes in serum lipids in women: a preliminary investigation. *Medicine and Science in Sports and Exercise* 1998;**30**:1114–8.

Nishi 1998

Nishi N, Jenicek M, Tataru K. A meta-analytic review of the effect of exercise on smoking cessation. *Journal of Epidemiology* 1998;**8**:79–84.

Paavola 2001

Paavola M, Vartiainen E, Puska P. Smoking cessation between teenage years and adulthood. *Health Education Research* 2001;**16**:49–57.

Parsons 2009

Parsons AC, Shraim M, Inglis J, Aveyard P, Hajek P. Interventions for preventing weight gain after smoking cessation. *Cochrane Database of Systematic Reviews* 2009, Issue 1. DOI: 10.1002/14651858.CD006219.pub2

Pate 1995

Pate PR, Pratt M, Steven SN, Haskell WL, Macera CA, Bouchard C, et al. Exercise and public health: A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 1995;**273**:402–7.

Pate 1996

Pate RR, Heath GW, Dowda M, Trost SG. Associations between physical activity and other health behaviors in a representative sample of US adolescents. *American Journal of Public Health* 1996;**86**:1577–81.

Patten 2001

Patten CA, Vickers KS, Martin JE, Williams CD. Exercise interventions for smokers with a history of alcoholism: Exercise adherence rates and effect of depression on adherence. *Addictive Behaviors* 2001;**27**:1–11.

Peretti-Watel 2003

Peretti-Watel P, Guagliardo V, Verger P, Pruvost J, Mignon P, Obadia Y. Sporting activity and drug use: Alcohol, cigarette and cannabis use among elite student athletes. *Addiction* 2003;**98**:1249–56.

Peretti-Watel 2002

Peretti-Watel P, Beck F, Legleye S. Beyond the U-curve: the relationship between sport and alcohol, cigarette and cannabis use in adolescents. *Addiction* 2002;**97**:707–16.

- Peto 1996**
Peto R, Lopez AD, Boreham J, Thun M, Heath C Jr, Doll R. Mortality from smoking worldwide. *BMJ* 1996;**52**: 12–21.
- Picavet 2010**
Picavet HS, Wendel-vos GC, Vreeken HL, Schuit AJ, Verschuren WM. How stable are physical activity habits among adults? The Doetinchem Cohort Study. *Medicine and Science in Sports and Exercise* 2010;**43**(1):74–79.
- Prochaska 1992**
Prochaska JO, DiClemente CC, Norcross JC. In search of how people change. Applications to addictive behaviors. *The American Psychologist* 1992;**47**:1102–14.
- Quit 1994**
QUIT. *Helping Smokers to Quit: A handbook for the practice nurse, health visitor and midwife*. London: Department of Health, 1994.
- Raw 1998**
Raw M, McNeill A, West R. *Smoking cessation guidelines for health professionals: A guide to effective smoking cessation interventions for the health care system*. London: HEA, 1998.
- Rodriguez 2004**
Rodriguez D, Audrain-McGovern J. Team sport participation and smoking: analysis with general growth mixture modeling. *Journal of Pediatric Psychology* 2004;**29**: 299–308.
- Rodriguez 2008**
Rodriguez D, Dunton GF, Tcherne J, Sass J. Physical activity and adolescent smoking: A moderated mediation model. *Mental Health and Physical Activity* 2008;**1**:17–25.
- Russell 1983**
Russell PO, Epstein LH, Erickson KT. Effects of acute exercise and cigarette smoking on autonomic and neuromuscular responses to a cognitive stressor. *Psychological Reports* 1983;**53**:199–206.
- Sasco 2002**
Sasco AJ, Laforest L, Benhaim-Luzon V, Poncet M, Little RE. Smoking and its correlates among preadolescent children in France. *Preventive Medicine* 2002;**34**:226–34.
- Schneider 2007**
Schneider KL, Spring B, Pagoto SL. Affective benefits of exercise while quitting smoking: influence of smoking-specific weight concern. *Psychology of Addictive Behaviors* 2007;**21**:255–60.
- Schroder 2003**
Schroder H, Elosua R, Marrugat J [REGICOR Investigators]. The relationship of physical activity with dietary cancer-protective nutrients and cancer-related biological and lifestyle factors. *European Journal of Cancer Prevention* 2003;**12**:339–46.
- Schuman 2001**
Schumann A, Hapke U, Rumpf HJ, Meyer C, John U. The association between degree of nicotine dependence and other health behaviours. Findings from a German general population study. *European Journal of Public Health* 2001;**11**:450–2.
- Scioli 2009**
Scioli ER, Biller H, Rossi J, Riebe D. Personal motivation, exercise, and smoking behaviors among young adults. *Behavioral Medicine* 2009;**35**(2):57–64.
- Sedgwick 1988**
Sedgwick AW, Davidson AH, Taplin RE, Thomas DW. Effects of physical activity on risk factors for coronary heart disease in previously sedentary women: A five-year longitudinal study. *Australian and New Zealand Journal of Medicine* 1988;**18**:600–5.
- Senti 2001**
Senti M, Elosua R, Tomas M, Sala J, Masia R, Ordovas JM, et al. Physical activity modulates the combined effect of a common variant of the lipoprotein lipase gene and smoking on serum triglyceride levels and high-density lipoprotein cholesterol in men. *Human Genetics* 2001;**109**:385–92.
- Shinton 1997**
Shinton R. Lifelong exposures and the potential for stroke prevention: The contribution of cigarette smoking, exercise and body fat. *Journal of Epidemiology and Community Health* 1997;**51**:138–43.
- Sorenson 1992**
Sorenson G, Goldberg R, Ockene J, Klar J, Tannenbaum T, Lemeshow S. Heavy smoking among a sample of employed women. *American Journal of Preventive Medicine* 1992;**8**: 207–14.
- Spence 2005**
Spence JCMcGannon KR, Poon P. The effect of exercise on global self-esteem: a quantitative review. *Journal of Sport & Exercise Psychology* 2005;**27**:311–334.
- Spring 2009**
Spring B, Howe D, Berendsen M, McFadden HG, Hitchcock K, Rademaker AW, et al. Behavioral intervention to promote smoking cessation and prevent weight gain: a systematic review and meta-analysis. *Addiction* 2009;**104** (9):1472–86.
- Stathopoulou 2006**
Stathopoulou G, Power MB, Berry AC, Smits JAJ, Otto MW. Exercise Interventions for Mental Health: A Quantitative and Qualitative Review. *Clinical Psychology: Science and Practice Volume* 2006;**13**:179–193.
- Stead 2008**
Stead LF, Perera R, Bullen C, Mant D, Lancaster T. Nicotine replacement therapy for smoking cessation. *Cochrane Database of Systematic Reviews* 2008, Issue 1. DOI: 10.1002/14651858.CD000146.pub3
- Steptoe 1989**
Steptoe A, Edwards S, Moses J, Matthews A. The effects of exercise training on mood and perceived coping ability in anxious adults from the general population. *Journal of Psychosomatic Research* 1989;**33**:537–47.

Takemura 2000

Takemura Y, Sakurai Y, Inaba Y, Kugai N. A cross-sectional study on the relationship between leisure or recreational physical activity and coronary risk factors. *Toboku Journal of Experimental Medicine* 2000;**192**:227–37.

Taylor 2000

Taylor AH. Physical activity, stress and anxiety: a review. In: Biddle SJH, Fox K, Boutcher S editor(s). *Physical activity and psychological well-being*. London: Routledge, 2000.

Taylor 2002

Taylor DH Jr, Hasselblad V, Henley SJ, Thun MJ, Sloan FA. Benefits of smoking cessation for longevity. *American Journal of Public Health* 2002;**92**(6):990–6.

Taylor 2007a

Taylor AH, Katomeri M. Walking reduces cue-elicited cigarette cravings and withdrawal symptoms, and delays *ad libitum* smoking. *Nicotine & Tobacco Research* 2007;**9**(11): 1183–90.

Taylor 2007b

Taylor AH, Ussher MH, Faulkner G. The acute effects of exercise on cigarette cravings, withdrawal symptoms, affect and smoking behaviour: A systematic review. *Addiction* 2007;**102**:534–43.

Taylor 2008

Taylor AH, Faulkner, G. Inaugural Editorial. *Mental Health and Physical Activity* 2008;**1**:1–8.

Taylor 2010

Taylor AH, Everson-Hock ES, Ussher M. Integrating the promotion of physical activity within a smoking cessation programme: findings from collaborative action research in UK Stop Smoking Services. *BMC Health Services Research* 2010;**10**:317.

Taylor 2011

Taylor A, Rowlands A, Green C, Taylor R, Greaves C, Campbell J, Ayres R, Byng R, Aveyard P, Ussher M, West R, Michie S. An exploratory trial to evaluate the effects of a physical activity intervention as a smoking cessation induction and cessation aid among the 'hard to reach'. Unpublished protocol.

USDHHS 1990

US Department of Health & Human Services. *The health consequences of smoking cessation: A report of the Surgeon General*. Rockville, MD: Public Health Service, Office on Smoking & Health, 1990.

USDHHS 2001

US Department of Health & Human Services. *Women and Smoking: A Report of the Surgeon General*. Rockville, MD: Public Health Service, Office of the Surgeon General, 2001.

USDHHS 2008

US Department of Health & Human Services. *Treating Tobacco Use and Dependence: 2008 Update. A report of the Surgeon General*. Rockville, MD: Public Health Service, 2008.

Ussher 2004

Ussher M, West R, Hibbs N. A survey of pregnant smokers' interest in different types of smoking cessation support. *Patient Education and Counselling* 2004;**54**:67–72.

Ussher 2007

Ussher M, Ah-Yoon M, West R, Straus L. Factors associated with exercise participation and attitudes to exercise among pregnant smokers. *Journal of Smoking Cessation* 2007;**2**: 12–16.

Vander Weg 2001

Vander Weg MW, Klesges RC, Eck Clemens LH, Meyers AW, Pascale RW. The relationship between ethnicity, gender, and short-term changes in energy balance following smoking cessation. *International Journal of Behavioral Medicine* 2001;**8**:163–77.

Vangeli 2011

Vangeli E, Stapleton J, Smit ES, Borland R, West R. Predictors of attempts to stop smoking and their success in adult general population samples: A systematic review. *Addiction* 2011 Jul 13 [Epub ahead of print] In press;in press:in press.

Verkooijen 2008

Verkooijen KT, Nielsen GA, Kremers SP. The Association between leisure time physical activity and smoking in adolescence: an examination of potential mediating and moderating factors. *International Journal of Behavioural Medicine* 2008;**15**(2):157–63.

Vickers 2003

Vickers KS, Patten CA, Lane K, Clark MM, Croghan IT, Schroeder DR, et al. Depressed versus nondepressed young adult tobacco users: differences in coping style, weight concerns and exercise level. *Health Psychology* 2003;**22**: 498–503.

Ward 2003

Ward KD, Vander Weg MW, Klesges RC, Kovach KW, Elrod MC, DeBon M, et al. Characteristics of highly physically active smokers in a population of young adult military recruits. *Addictive Behaviors* 2003;**28**:1405–18.

Weekley 1992

Weekley CK, Klesges RC, Reyle G. Smoking as a weight-control strategy in a university population. *Addictive Behaviors* 1992;**17**:259–71.

West 1989

West R, Hajek P, Belcher M. Severity of withdrawal symptoms as a predictor of outcome of an attempt to quit smoking. *Psychological Medicine* 1989;**19**:981–5.

West 1997

West R. Getting serious about smoking cessation: a review of products services and techniques. No Smoking Day Report, London 1997.

Williams 2008

Williams DM, Lewis BA, Dunsiger S, King TK, Jennings E, Marcus BH. Increasing fitness is associated with fewer depressive symptoms during successful smoking abstinence

among women. *International Journal of Fitness* 2008;**4**: 39–44.

Woodhouse 1990

Woodhouse K, Rigg E. *Quit & Get Fit: A guide to running a six week course*. London: HEA, 1990.

References to other published versions of this review

Ussher 2000a

Ussher MH, Taylor AH, West R, McEwen A. Does exercise aid smoking cessation? A systematic review. *Addiction*

2000;**95**:199–208.

Ussher 2000b

Ussher M, West R, Taylor AH, McEwen A. Exercise interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 2000, Issue 3. [DOI: 10.1002/14651858.CD002295]

Ussher 2005

Ussher M. Exercise interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 2005, Issue 1. DOI: 10.1002/14651858.CD002295.pub2

* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Bize 2010

Methods	Country: Switzerland Randomized: computer generated	
Participants	481, mean age 42, mean CPD 27, sedentary: < 150 mins moderate intensity physical activity per week and <60 mins vigorous intensity activity	
Interventions	(a) Intervention: moderate-intensity group-based CV activity, 45 mins, weekly for 9 weeks + 15 mins CP for 9 weeks (including NRT prescription) (b) Control: 9 weeks of 15 mins per week CP (including NRT prescription) + Health Education for equal time as exercise intervention (not exercise) Exercise started one week before quit date	
Outcomes	Continuous abstinence Validation: CO <10ppm Follow up: 5 weeks, 5 mths & 47 weeks after quit date	
Notes	Contact time balanced between a and b First included as Cornuz 2007	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	'Remotely and randomly generated by a computer', block size 50
Allocation concealment (selection bias)	Low risk	'Concealment of allocation was secured by means of sealed envelopes.' Not stated whether those delivering the intervention were aware of the possible treatment allocations
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	62 post randomization exclusions: 11 I & 2 C did not attend first group session, 1 C pregnant, 20 I & 28C regular exercisers, or marijuana users. 45% I & 38% C lost to f-up at one year, included as smokers in analysis

Ciccolo 2011

Methods	Country: USA Randomization: computer generated list of numbers	
Participants	26, mean age 37 (36.5), mean CPD 18, exercise < 60 min/week	
Interventions	(a) Resistance training with equipment: alone, facility, 60 min, 2 times/week for 12 weeks, 10 exercises, 65-75% est max, 10 reps, weeks 1-3: 1 set, weeks 4-2: 2 sets, + CP (single 1-20 min counselling + nicotine patches, received prior to randomization). (b) CP as (a) + health education video, 25mins, 2 times/week for 12 weeks Exercise began on the quit day	
Outcomes	7 day PPA, prolonged abstinence (allowing 2 week grace period after quitting) Validation: CO <10ppm Follow-up: 3, 6 months	
Notes	Number of contacts balanced between a and b but contact time was not Following four 30 min pre-randomization sessions (orientation, consent and baseline questionnaires), over a 2 week run-in period, 147 were excluded	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly generated by a computer
Allocation concealment (selection bias)	Unclear risk	No detail given
Incomplete outcome data (attrition bias) All outcomes	Low risk	1 post randomization exclusion: developed lung cancer. 8% I & 15% C lost to f-up at 3 mth, 38% I & 54% C lost to f-up at 6 mth; all included as smokers in analysis

Hill 1985

Methods	Country: Canada Randomized	
Participants	26 women, 10 men, mean age 40, mean CPD 32	
Interventions	(a) Intervention: CV activity: various, group, facility, 30 mins, twice weekly for 5 weeks + home activity + CP twice weekly for 5 weeks (b) Control, CP alone Exercise began on quit date	

Hill 1985 (Continued)

Outcomes	7 day PP abstinence Validation: CO Follow up: 1, 3 ,6 months	
Notes	Contact time not balanced	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Method not stated
Allocation concealment (selection bias)	Low risk	No details given
Incomplete outcome data (attrition bias) All outcomes	Low risk	One participant not attending follow ups was counted as a smoker

Hill 1993

Methods	Country: USA Recruitment: community volunteers, smoking at least 30 yrs, not currently walking for exercise Randomization: in blocks of 8 to 12, method not described	
Participants	43 women, 39 men, mean age 59, mean CPD 28, irregular walkers. (excludes 4 treatment drop-outs and 8 non-attenders)	
Interventions	(a) Intervention 1: Walk: group/individual, facility/ home, 15-35 min, 60-70% HR reserve, 1-3 times/week for 12 weeks (b) Intervention 2: as (a) + CP 1-4 times/week for 12 weeks (c) Intervention 3: CP as (b) + nicotine gum. (d) Control: , CP alone Exercise began before quit date	
Outcomes	5-day PP abstinence, Validation: CO <10ppm Follow up: 1, 4, 9 months	
Notes	(b) compared to (d) for effect of exercise programme	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Method not stated

Hill 1993 (Continued)

Allocation concealment (selection bias)	Low risk	No details given
Incomplete outcome data (attrition bias) All outcomes	Low risk	Four individuals dropped out and were excluded from the analysis. The main findings were the same with or without the four dropouts

Kinnunen 2008

Methods	Country: USA Randomization: Method not stated
Participants	182 women, mean age 39, mean CPD 19, exercise < 3 times a week
Interventions	(a) Intervention 1: CV equipment, individual, facility, 40 min, 60-80% HR max (twice a week for 5 weeks, then once per week for 14 weeks) + CP (once a week for 19 weeks) + nicotine gum (b) Intervention 2: CP and nicotine gum as (a) + health education for same number of sessions as for exercise in (a) (c) Control: CP and nicotine gum as (a)
Outcomes	Prolonged abstinence Validation: CO, cotinine Follow-up: 1 week, 1, 4, 12 months
Notes	Contact time balanced between (a) and (b). (b) used as control condition in forest plot. 2/34 quit in control (c)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomized at baseline visit, method not stated. Recruitment to condition (c) discontinued during trial due to poor early outcomes. Availability of facilities allowed for a greater number of participants to be randomized into the exercise intervention than into the equal contact condition.
Allocation concealment (selection bias)	Low risk	No details reported. No evidence of important differences in baseline characteristics between groups
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not an intention to treat analysis as 263 women were randomized, but only those considered to have made a quit attempt

Kinnunen 2008 (Continued)

		(92/125 in (a), 56/96 in (b), 34/42 in (c) were included in the analysis
--	--	--

Marcus 1991

Methods	Country: USA Randomization: method not stated
Participants	20 women, mean age 39, mean CPD 28, exercise < once a week.
Interventions	(a) CV equipment: group, facility 30-45 min, 70-85% HR max, 3 times/week for 15 weeks + CP (twice a week for 4 weeks). (b) CP only (twice a week for 4 weeks) Exercise began before quit date
Outcomes	7-day PP abstinence Validation: saliva cotinine <10ng/ml. Follow up: 1, 3, 12 months
Notes	Contact time not balanced

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Method not stated
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	One participant did not attend follow ups and was counted as a smoker

Marcus 1995

Methods	Country: USA Randomization: method not stated
Participants	20 women, mean age 38, mean CPD 23, exercise less than once a week
Interventions	(a) CV equipment: group, facility, 30-40 min, 60-85% HR reserve, (3 times/week for 15 weeks) + CP (once a week for 12 weeks). (b) CP as (a) + health education 3 times/week for 15 weeks Exercise began before quit date
Outcomes	7 day PPA Validation: saliva cotinine <10ng/ml. Follow-up: 1, 3, 12 months

Marcus 1995 (Continued)

Notes	Contact time balanced between a and b	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Low risk	Those delivering the intervention were not blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not stated

Marcus 1999

Methods	Country: USA Randomization: Computer-generated	
Participants	281 women, mean age 40, mean CPD 22 exercise < twice a week.	
Interventions	(a) Intervention: CV equipment: group, facility, 30-40 min, 60-85% HR reserve, (3 times/week for 12 weeks) + CP (once a week for 12 weeks). (b) Control: CP as (a) once/week for 12 weeks + health education 3 times/week for 12 weeks Exercise began before quit date	
Outcomes	Continuous abstinence, Validation: saliva cotinine < 10ng/ml, CO < 8ppm. Follow up: 3, 12 months	
Notes	Contact time balanced between (a) and (b)	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	'The randomization code for group assignment was generated by a computer program'
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	44% (a) and 50% of (b) lost at 12 months, included as smokers

Marcus 2005

Methods	Country: USA Randomization: Computer-generated
Participants	217 women, mean age 43, mean CPD 21 exercise ≤ 90 mins /wk.
Interventions	(a) Intervention: CV various: group/individual, home/facility, 45 min, 45-59% HR reserve, (facility: once/week for 8 weeks, goal: 165 min/week) + CP (once a week for 8 weeks). (b) Control: CP as (a) once/week for 8 weeks + health education once/week for 8 weeks Exercise began before quit date
Outcomes	Continuous abstinence, Validation: saliva cotinine < 10ng/ml, CO < 8ppm. Follow up: 3, 12 months
Notes	Contact time balanced between a and b

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	'Group assignment was based on a randomization code generated by a computer software program and was stratified based on participant's patch usage decision'
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	75% (a) & 68% (b) did not attend 12-month follow up session, included as smokers

Martin 1997

Methods	Country: USA Randomization: method not stated
Participants	92 women, 113 men, problem drinkers, mean age 42, mean CPD 27, exercise < once a week
Interventions	(a) Intervention 1: CV activity: various, group/individual, facility/home, 15-45 min, 60-75% HR max, (once/week for 4 weeks) + CP: (once/week for 12 weeks) (b) Intervention 2: CP as (a) + nicotine gum. (does not contribute to this review) (c) Control: Different CP (once/week for 8 weeks) and Nicotine Anonymous meetings (3 times/week for 4 weeks) Exercise began on quit date

Martin 1997 (Continued)

Outcomes	7-day PP abstinence Validation: CO < 10ppm Follow up: 7 days, 6, 12 months	
Notes	Contact time not matched, different cessation programmes	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomized, method not stated
Allocation concealment (selection bias)	Low risk	No details reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Numbers lost to follow up not reported, but all participants included in denominators

McKay 2008

Methods	Country: USA Randomization: Computer-generated online	
Participants	2318, 78% > 30 years of age, 83% > 10 CPD	
Interventions	(a) Web-based, multi-step program designed to encourage physical activity with a motivational component (e.g. exploring benefits and barriers) and a behavioral action plan (e.g. weekly schedules), plus access to a peer support forum (b) Web-based, multi-step program introducing users to the key concepts and strategies of a behavioral quit smoking program, including a peer support forum and 'ask the expert' tool Did not state when exercise began relative to the quit date	
Outcomes	7 day point-prevalence abstinence Validation: No biochemical validation as outcomes reported online or via telephone Follow up: 3, 6 months	
Notes	Exercise condition (a) intended to be an attention placebo control condition	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	randomly generated by a computer via the Internet

McKay 2008 (Continued)

Allocation concealment (selection bias)	Unclear risk	No detail given
Incomplete outcome data (attrition bias) All outcomes	Low risk	60.2% I & 61.3% C lost to f-up at 6 months, included as smokers in analysis

Prapavessis 2007

Methods	Country: NZ Randomization: Computer-generated
Participants	142 women, mean age 38, exercise < twice a week. (excludes 21 pretreatment drop-outs)
Interventions	(a) Intervention 1: CV activity: various, group/facility, 45 min, 60-75% HR reserve, (3 times/week for 12 weeks) + CP (three times/week for 12 weeks). (b) Intervention 2: exercise as (a) plus nicotine patches (c) Intervention 3: Cognitive behavioural cessation programme three times/week for 12 weeks. (d) Intervention 4: as (c) plus nicotine patches. Exercise began before quit date
Outcomes	Continuous abstinence, Validation: saliva cotinine < 10ng/ml, CO < 10ppm. Follow up: 6 weeks, 3, 12 months
Notes	Contact time balanced between a, b, c and d.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated randomization.
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	21 pretreatment dropouts excluded. Loss to follow up higher in (a)+(b), 40%, than in (c)&(d), 23% (p=.05). Not stated whether those lost to follow up were counted as smokers

Russell 1988

Methods	Country: USA Randomization: method not stated
Participants	42 women, mean age 28, mean CPD 23.
Interventions	(a) Intervention 1: Walk/jog: group/individual, facility/home, 20-30min, 70-80% HR max, (3 times/week for 9 weeks)+ CP: (4 times/week for 1 week) (b) Intervention 2: CP as (a) + health education (once a week for 9 weeks) (c) Control: CP as (a) Exercise began after quit date
Outcomes	quit (not defined) Validation: CO Follow up: 1, 4, 16 months
Notes	No difference between groups Contact time balanced between (a) and (b)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not stated

Taylor 1988

Methods	Country: USA Randomization: method not stated
Participants	58 men, post-acute myocardial infarction
Interventions	(a) Intervention 1: CV activity: various, group, facility, 30-40 min, 70-85% HR max, (i) [3, 23] (ii) [3, 8] + CP x 1 session; (b) Intervention 2: (i, ii) as (a) home: 20 min, x 5/wk (c) Control: Fitness test at end of treatment only (d) Intervention 3: Fitness test at baseline & end of treatment, cessation programme as (a)
Outcomes	Validation: plasma thiocyanate Follow up: 23 weeks
Notes	Contact time not balanced

Taylor 1988 (Continued)

<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Low risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not stated

Ussher 2003

Methods	Country: UK Randomization: Computer-generated	
Participants	188 women, 121 men, mean age: 43, mean CPD: 22; < 5 days of 30 mins moderate intensity exercise per week	
Interventions	(a) Intervention: Exercise counselling (once a week for 7 weeks) + CP (once a week for 7 weeks). (b) Control: Cessation programme as (a) once/week for 7 weeks + brief health education once/week for 7 weeks. Exercise began before quit date	
Outcomes	Continuous abstinence, Validation: CO < 10ppm. Follow up: 6 weeks, 12 months	
Notes	Contact time balanced between (a) and (b)	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Computer generated
Allocation concealment (selection bias)	Low risk	Those delivering the intervention were not blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	27 participants could not be contacted at the 12 month follow up and were counted as smokers

CO: carbon monoxide

CP: cessation programme

CPD: cigarettes per day

CV: cardiovascular

HR: heart rate

PP: point prevalence

ppm: parts per million

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Al-Chalabi 2008	Follow-up less than six months and combined isometric exercise and body-scanning interventions; therefore it was not possible to assess the specific effects of exercise
Arbour-Nicitopoulos 2011	Acute study
Caliani 2004	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Chaney 2008	Follow up was less than six months
Cinciripini 1996	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Clark 2005	A non-exercise control group was not included
Copeland 2006	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Daley 2004	Acute study
Daniel 2004	Acute study
Daniel 2006	Acute study
Daniel 2007	Acute study
Elibero in press	Acute study
Everson 2006	Acute study
Everson 2008a	Acute study
Faulkner 2010	Acute study
Fortmann 1995	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise

(Continued)

Grove 1993	The outcome was withdrawal symptoms rather than smoking abstinence
Grove 2006	Had sleep disturbance as the main outcome, rather than smoking abstinence
Haasova 2011	Acute study
Horn 2011	Not all the participants were motivated to quit smoking
Hurt 1992	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Hurt 1994	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Hwang 2010	A non-exercise control group was not included. Also follow-up was less than 6 months
Janse van Rensburg 2008	Acute study
Janse van Rensburg 2009a	Acute study
Janse van Rensburg 2009b	Acute study
Janse van Rensburg 2010	Acute study
Jones 2001	Included an exercise programme in a self-help manual as part of a multiple component programme. Therefore it was not possible to examine the specific effects of exercise
Jonsdottir 2001	A quasi-experimental study comparing a smoking cessation programme plus weekly group exercise with the smoking cessation programme only. Participants were not randomly allocated to the groups
Leclarungrayub 2010	Did not include smoking abstinence as an outcome.
McClure 2009	Included an exercise counselling as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
McClure 2011	Included an exercise counselling as part of a multiple risk factor intervention. Therefore it was not possible to examine the specific effects of exercise on smoking cessation
McIver 2004	There was no control group
Mikhail 1983	Acute study
Oenema 2008	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Ortega Sanchez-P 2006	Retrospective study

(Continued)

Pomerleau 1987	Acute study
Prochaska 2008	Included an exercise counselling as part of a multiple component relapse prevention programme. Therefore it was not possible to examine the specific effects of exercise. Also, follow-up was less than six months
Ramsay 2004	Included an exercise programme as part of a multiple component smoking cessation programme. Therefore it was not possible to examine the specific effects of exercise
Reeser 1983	Acute study
Scerbo 2010	Acute study
Spring 2004	Combined an exercise programme with a dietary intervention. Therefore it was not possible to examine the specific effects of exercise
Taylor 2005	Acute study
Taylor 2006a	Acute study
Taylor 2006b	Acute study
Thayer 1993	Acute study
Ussher 2001	Acute study
Ussher 2006	Acute study
Ussher 2008	Did not include a control group
Ussher 2009	Acute study
Vander Weg 2008	Included an exercise programme as part of a multiple component programme for smoking cessation and management of weight and blood pressure. Therefore it was not possible to examine the specific effects of exercise
Vickers 2005	The follow up was less than six months
Vickers 2009	Follow-up was less than six months.
Whiteley 2007	Did not include a control group
Williams 2010	Follow-up was less than six months.
Williams 2011	Acute study
Zwick 2006	Unable to obtain details of study from authors

Characteristics of ongoing studies *[ordered by study ID]*

Bock 2010

Trial name or title	Yoga for women attempting smoking cessation
Methods	RCT
Participants	60 women
Interventions	8-week programme with 1-hour per week of cognitive-behavioural smoking cessation group treatment. Participants randomly assigned to receive either a supplemental wellness programme (contact-control) or 1 hour twice weekly of yoga.
Outcomes	The primary outcome is 7-day point prevalence abstinence at 6 month follow up
Starting date	2007
Contact information	Professor Beth Bock Bbock@lifespan.org
Notes	

Jung 2010

Trial name or title	Exercise for relapse prevention during smoking cessation
Methods	RCT
Participants	440 women
Interventions	Following a 14 weeks supervised exercise programme, randomised to one of four 'home-based' conditions: (a) exercise maintenance, (b) exercise maintenance plus relapse prevention booklet, (c) relapse prevention booklets plus contact, (d) contact only
Outcomes	Primary outcome is continuous abstinence at 3 and 12 months after the initial 14 week treatment programme
Starting date	
Contact information	Dr Lindsay George, lfitzgeo@uwo.ca
Notes	

Maddison 2010

Trial name or title	Pragmatic randomized controlled trial of exercise for smoking cessation
Methods	RCT
Participants	1400

Maddison 2010 (Continued)

Interventions	Usual care (cessation programme plus NRT) plus exercise programme versus usual care alone
Outcomes	Continuous abstinence and 7 day pp abstinence at 6 months after the quit date
Starting date	
Contact information	Professor Ralph Maddison r.maddison@ctr.u.auckland.ac.nz
Notes	Contact time not equal between conditions

Ussher 2011

Trial name or title	Pragmatic trial of physical activity for smoking cessation during pregnancy
Methods	RCT
Participants	866 pregnant smokers
Interventions	Physical activity intervention plus cessation programme versus cessation programme alone
Outcomes	Prolonged abstinence at end of pregnancy and 6 months post-partum
Starting date	2009
Contact information	Dr Michael Ussher mussher@sgul.ac.uk
Notes	Contact time not equal between conditions

Studies in Progress

DATA AND ANALYSES

Comparison 1. Exercise component versus smoking cessation programme only

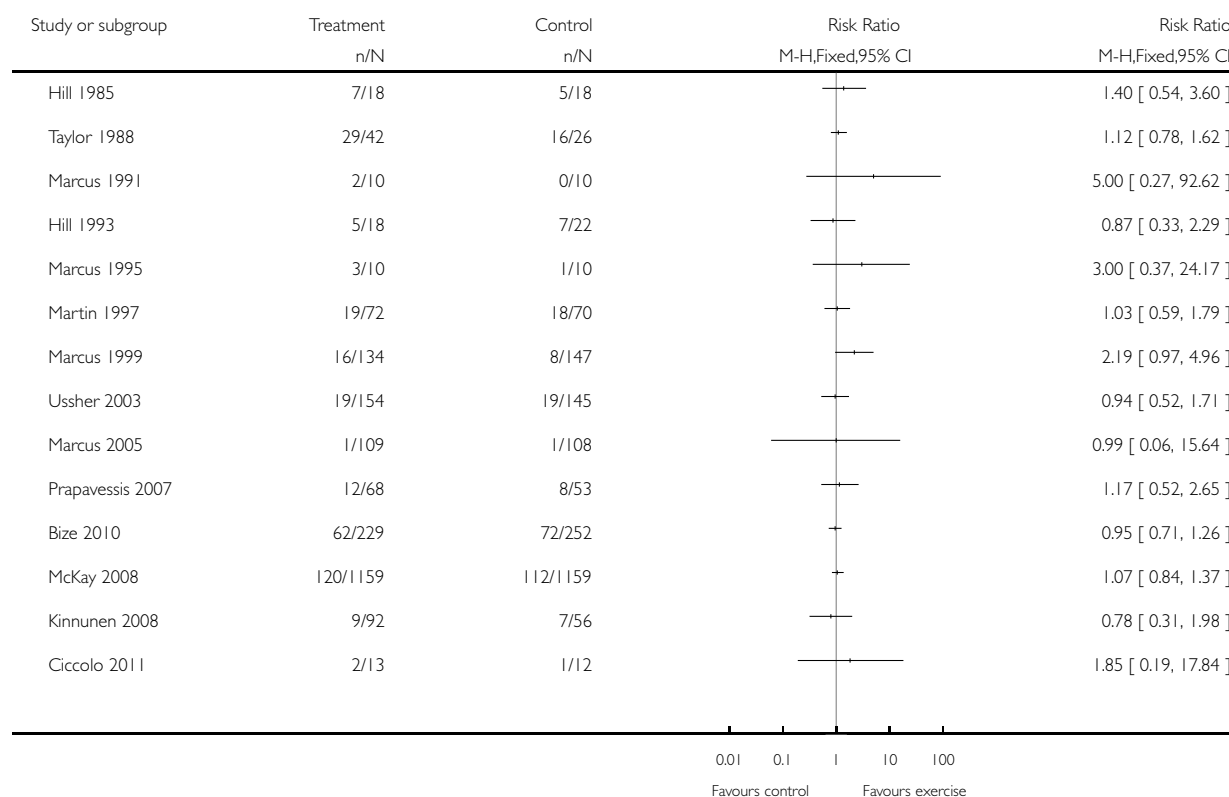
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Smoking cessation at longest follow up	14		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 1.1. Comparison 1 Exercise component versus smoking cessation programme only, Outcome 1 Smoking cessation at longest follow up.

Review: Exercise interventions for smoking cessation

Comparison: 1 Exercise component versus smoking cessation programme only

Outcome: 1 Smoking cessation at longest follow up



APPENDICES

Appendix I. Studies on the acute effect of exercise

Study	Design	Subject characteristics	Exercise characteristics	Measures	Outcome
Mikhail 1983	Within subjects. 1 hr in lab post-treatment + 23 hr post-lab. Abstinence period: 30 mins	18 M, inactive, low-moderate fitness. Mean age = 26yrs. Mean time as smoker = 10 yrs. Smoked ≥ 1 pack/day for 3 yrs. Non-quitters	All 10 mins. (a) & (b) = + 4-5 min cool down) (a) cycle @ 104 bpm (66-69% max hr) (b) cycle @ 120 bpm (82-85% max hr) (c) passive (reading)	60 mins of surreptitious observation in lab with freedom to smoke/read. -Time to 1st puff. - Duration of 1st lit cig. & no. of puffs. -No. cigs in follow-up 60 mins + 23 hr. (adjusted for wake hrs)	(a) & (b) less time with 1 st lit cig. cf. (c). (a) & (b) not different. No other sig. diffs. *
Reeser 1983	Between-subjects (matched by age & sex) then randomized. Data presented from 2 lab sessions with same treatment condition. No abstinence period prescribed but mean time = 30 mins.	25 F & 12 M, inactive. Mean age = 24 yrs. Mean CPD = 23. Mean time as smoker = 8.4 yrs. Smoked ≥ 1 pack/day for 2 yrs. Non-quitters	20 mins (a) = 3 min stretch + 13 min ex. + 2 min cool-down + 2 min stretch. (a) cycle @ 140 bpm (60% max HR) (b) stretch & isometrics (c) passive	30 mins of surreptitious observation in lab with freedom to smoke/read. SAI. Time to 1 st cig & no. of puffs & time lit. No. who smoked. Time to 1 st cig after leaving lab. (self-reported)	Data averaged from 2 sessions: (b)<(c) on no. of puffs (ES=0.69). (b)>(c) on time to 1 st cig (net diff = 24 mins) (ES=1.0) (a=14 min; b= 31 min; c=7 min). 28% in (a & b) and 15% (in c) didn't smoke during 30 min observation
Pomerleau 1987	Within subjects. Follow up to 20 mins post-exercise. Abstinence period: 30 mins.	10 M, inactive healthy. Mean age = 24 yrs. Mean CPD = 28	Both 30 mins cycling (a) 80% VO ₂ max (b) 30% VO ₂ max.	POMS, SWS	(a) v. (b) NS for all measures *
Thayer 1993	Within subjects. Follow up immediately post-exercise. Abstinence period: 45 mins.	5 M & 11 F, Age = 18-44 years. Smoked 1-2 packs per day	5 mins of either (a) brisk walk (b) inactivity	Short AD-ACL (energy & tension), urge to smoke, time to next cig	(a) reduced Urge to smoke, increased energy & time to next cig. (17 vs. 9 mins delay). *

(Continued)

Marcus 1999 (reported in Bock 1999)	Within (pre-post exercise/ control) subjects. During smoking cessation	Group 1= 24 F Group 2 = 44 F Both groups inactive. Mean age = 38 yrs. Mean CPD = 20	(a) 30-40 mins 60-85% HRR, aerobic activity (group 1 & 2) (b) Equal contact passive. All grps (a1, a2, & b) were involved in an 11 wk trial	PANAS, ESR, & cravings.	(a) Group 1 & 2 reduced negative affect, nicotine withdrawal and cigarette cravings, in all weeks (5-10) after quit date. No effect on positive affect. *
Ussher 2001	Between subjects (randomly assigned). Assessments Pre (T1), mid (T2), immediately post (T3), 5 (T4) & 10 mins post (T5) treatment. Abstinence period: 15 hrs	78 inactive M & F, Mean CPD = 18 . Mean age = 36 yrs. Mean FTND = 5.9. Mean baseline SoD = 6.4 (ranging from 6.1-6.6)	(a) 40-60% HRR, cycling+video; (b) video control; (c) passive control, All for 10 min + 1-2 min warm-up	MPSS, plus Tiffany 'desire to smoke' item	(a) < (b & c) for desire & SoD to smoke, irritability, restlessness, tension, depression, poor concentration, stress at T2, T3, T4 & T5 (not SoD). ES (a) v (c) for SoD to smoke = 0.54, 0.47, 0.27, & 0.14, at T2, T3, T4 & T5, respectively. Effects of exercise greater for less active
Daley 2004	Between subjects. Pre- (T1), post- (T2), 30 (T3) & 60 mins (T4) post-treatment. Abstinence period: c.17 hrs	16 sedentary M & F. Mean CPD = 13 Mean age = 21 yrs.	a) 60-65% age predicted maximum HR cycling; (b) passive video on smoking cessation. Both for 30 min	PANAS & SWS	(b) maintained negative affect while (a) increased it. No other sig. time X group interaction. ES (a) v (b) for cravings = 0.53, 0.47 & 0.74, at T2, T3 & T4 (all non sig at P<.05)
Daniel 2004	Between subjects (randomly assigned). Pre- (T1), mid- (T2), 0 (T3), 5 (T4) & 10 mins (T5) post-treatment. Abstinence period: 11-15 hrs	84 inactive M & F. Mean CPD = 17 Mean age = 30 yrs. Mean FTND = 4.0. Mean baseline SoD = 4.1	(a) 40-60% HRR cycling; (b) 10-20% HRR cycling; (c) passive control. (a) & (b) achieved target intensity prior to 2.5 mins (during warm-up) and maintained	5 MPSS items, plus desire & SoD to smoke items.	Results presented as change scores from baseline. (a) reduced cf (c) for: desire (at T2 & T3); SoD to smoke (at T3 & T4); irritability & restless (at T4 & T5); tension, (at T4). (b) reduced cf (c)

(Continued)

			until 5 mins, then 2.5 min warm down		poor concentration (at T3). Condition differences, (a) < (c) ES = 1.16, 0.97, 0.58, 0.24 (at T2, T3, T4 & T5, respectively) for SoD
Taylor 2005 Taylor 2006a	Within subjects. Randomly ordered. Assessments at Pre (T1), mid (T2), immediately (T3), 10 mins (T4), 20 mins (T5) post-treatment. Abstinence period: >15 hrs	10 M & 5 F, active. Mean CPD = 17 Mean age = 26 yrs. Mean FTND = 4.0. Mean baseline SoD = 5.8	(a) Self-paced 1 mile treadmill brisk walk (means = 10.8 RPE; 25% HRR, 18 mins), (b) passive waiting. (a) also had 2 min warm-up and cool down	MPSS, desire & SoD to smoke, 2 factor 32-item QSU. FS & FAS. POMS scales	(a) < (b) desire & SoD to smoke at T2, T3, T4, & T5 and both QSU scales at T5. Reduced tension & increased FS at T5 & increased FAS at T3. For desire to smoke, ESs=3.9, 3.7, 3.7, 3.1; & SoD ESs=3.8, 4.6, 2.8, 1.6 at T2, T3, T4 & T5, respectively
Ussher 2006	Between subjects (randomly assigned). Assessments at Pre (T1), immediately (T2), 5 mins (T3), 10 mins (T4), 15 mins (T5), & 20 mins (T6) post-treatment. Mean abstinence period: 17.3 hrs	27 F & 33 M. Mean CPD = 19 Mean age = 32 yrs. Mean FTND = 3.9. Mean baseline SoD = 5.2	5 mins of: (a) seated isometric exercise; (b) body scan; (c) sitting passively	SoD to smoke, & MPSS items.	(a) < (c) for SoD to smoke (at T2 & T3), ESs=0.27, 0.29, respectively), poor concentration (at T3, T4, & T5). No effects at T6. (b) < (a & c) on baseline scores which confounded results
Everson 2006	Between subjects (stratified, by gender, randomly assigned) design. Measures at pre- (T1), mid- (T2), 5 (T3) & 30 min (T4) post-treatment. Mean abstinence period: 17.2 hrs	19 M & 18 F, less active. Mean age = 17.7 yrs. Mean CPD = 13.6 Non-quitters. Mean dependence = 7.2 (on 0-10 scale of HONC). SoD = 3.4 (estimated from original 0-5 scale)	Both 10 mins cycle (a) (RPE = 12.3, HR= 112 bpm, 55% age-predict HR max). (b) (RPE = 8.3, HR =89 bpm, 44% age-predicted HR max).	SoD to smoke, MPSS, SEES-PWB, SEES-PD, SEES-fatigue.	No differences between groups at any time point (except higher SEES-PD only during (a)(not after). ES (a) v (b) for SoD = 0.50, 0.15 & 0.47 at T2, T3 & T4 (all non sig at p<.05), with lower cravings for (a)

(Continued)

Daniel 2006	Between subjects (random assigned). Measures at pre- (mean of -10, -5 & 0 mins), during- (mean of mid and end of treatment), & post-treatment (mean of + 5 & + 10 min). Mean abstinence period: 13.6 hrs	23 M & 17 F, sedentary. Mean age = 23.4 yrs. Mean CPD = 14. Non-quitters. Mean FTND = 3.0 Mean baseline SoD = 4.0	(a) 10 mins cycle (40-60% HRR). (b) Passive (Cognitive distraction task)	SoD to smoke, MPSS, PANAS	(a) < (b) during and after treatment for desire & SoD, difficulty concentrating and stress. ES (a) v (b) for cravings = 2.0 & 1.0 during and post treatment, for both desire and SoD to smoke. (a) < (b) during treatment for 5 other MPSS items but due to increase during cognitive distraction task rather than reduction during exercise
Katomeri 2007	Within subjects. Randomly ordered. Pre-, Mid- & post-exercise + pre- & post-smoking cue. Ad libitum smoking. Abstinence period 2 hrs.	17 M & 13 F, moderately active. Mean age = 21.9 yrs Mean CPD = 13.7. Non-quitters. Mean FTND = 3.5. Mean baseline SoD = 5.2	(a) 15 mins self-paced treadmill brisk walk (means = RPE - 12.2, HRR - 37.3%). (b) passive waiting	Desire & SoD to smoke. MPSS, FS & FAS. 2 factor 10-item QSU. Time to next cig. after leaving lab. (from phone text)	(a) < (b) Both desire & SoD to smoke measures, both QSU scores & 7 MPSS items during & post-treatment (ES for desire and SoD ranged from 1.5 to 3.1; mean = 2.3). (a) > (b) for change in desire to smoke in response to lit cig. cue. (ES = 0.61). (a) < (b) for time to next cig (66 v. 31 min.) (ES = 0.85)
Taylor 2007a Taylor 2006b	Between subjects (randomly assigned). Measures at baseline, mid- & post-ex. then pre & post 3 tasks: Stroop, speech task, & handled lit cig. Ad lib. smoking. Abstinence period: 2 hrs	34 F & 26 M, moderately active. Mean age = 28.5 years. Mean CPD = 15 Non-quitters. Mean FTND = 3.5. Mean baseline SoD = 4.6.	(a) 15 mins self-paced treadmill brisk walk (means = RPE = 11, HRR = 24%); (b) passive waiting. (a) also had 2 min warm-up.	Desire & SoD to smoke. MPSS, Time to next cig. after leaving lab. (from phone text). SBP/DBP & HR	(a) < (b) for Desire & SoD & 7 MPSS items, at all assessments from mid-ex to post lit cig. ES for desire ranged from 1.04-1.78 with mean = 1.62. ES for SoD ranged from 1.2-2.07 with

(Continued)

					mean = 1.45. (a) attenuated responses to lit cig. cue for SoD to smoke (ES = 0.61), tension, stress, poor concentration & SBP. (a) also attenuated SBP & DBP responses to Stroop & speech tasks, and restlessness to Stroop. (a) > (b) for time to next cig (84 v 27 min) (ES=1.20)
Daniel 2007	Between subjects (randomly assigned). Measures at pre- (mean of -10, -5 & 0 mins), during- (mean of mid and end of treatment) , & post-treatment (mean of + 5 & + 10 min). Mean abstinence period: 13 hrs	22 M & 23 F, sedentary. Mean age = 24 yrs. Mean CPD = 14. Non-quitters. Mean FTND = 4.1. Mean baseline SoD = 4.4	3 groups = positive, negative or neutral expectations of effects of exercise. All groups cycled 10 mins cycle (40-60% HRR) (plus 1-2 min warm-up)	SoD & MPSS	All groups reduced SoD & MPSS items from pre- to during & post exercise (ES = 0.4-0.9)(except restlessness & poor concentration during exercise). No difference between groups
Scerbo 2010	Within subjects (randomly assigned order). Measures at pre- (T1) , mid- (T2), & 0 (T3), 10 (T4), 20 (T5), & 30 (T6) min post-treatment. Abstinence period > 3hrs + smoking cues at baseline	10 M & 8 F Mean age = 26 yrs. Moderately active. Non-quitters. Mean FTND = 4.4. Mean baseline SoD = 5.5	All 15 mins. (a) Walking (RPE = 13.4, HR=133 bpm, HRR= 45-50%). (b) Running (RPE = 16.2, HR =170 bpm, HRR=80-85%). (c) Passive seating (HR= 80 bpm)	Desire & SoD, cortisol	(a) & (b) < (c) for SoD at T2 & T3, and only (b) < (c) at T4. (a) & (b) < (c) for desire at T2, T3 & T4 and only (b) < (c) at T5. By 30 mins, no differences in cravings between (a), (b) & (c)
Janse van Rensburg 2008	Within subjects. Randomly ordered. Pre-, Mid- (not QSU-brief) & post-exercise, + 5, 10 & 15 mins post-treatment. Abstinence period	15 M & 8 F. Mean age 23.1 yrs. Mean CPD 13.7. Non-quitters. Mean FTND= 3.4. Mean baseline Desire to Smoke = 5.0	(a) 15 mins self-paced treadmill brisk walk (+ 2 mins warm-up & 1 min cool down) (means = RPE - 10.8, HR - 113). (b) passive waiting	Desire to smoke. 2 factor 10-item QSU. Other measures of cognitive functioning using Stroop colour-word task not reported here	(a) < (b) Desire to smoke at T2, T3, T4 (ES = 1.46, 1.20 and 0.93, respectively). (a) < (b) for both QSU measures at T3, T4 & T5 (ES for Factor 1 = 1.96,

(Continued)

	15 hrs.				2.04 and 1.39, & Factor 2 = 1.47, 1.22 and 0.98, respectively)
Everson 2008a	Between subjects (random assigned). Measures at pre- (T1), mid- (T2), & 5 (T3) & 30 (T4) min post-treatment. Mean abstinence period: 17 hrs	25 M & 20 F. Mean age = 21.8 yrs. Mean CPD = 13.6. Non-quitters. Mean FTND = 3.4. Mean baseline SoD = 4.6. HONC = 7.6	All 10 mins. (a) Cycle (RPE = 12.5, HR=131 bpm, HRR= 50%). (b) Cycle (RPE = 14.8, HR =155 bpm, HRR=68%). (c) Passive seating.	SoD, MPSS & SEES	(a) & (b) < (c) at T2 & T3 for SoD, and only (a) < (c) for total MPSS & SEES (positive well-being) at T3. (b) < (c) for composite MPSS & SEES-PD, and (b) > (c) for SEES-PWB at T3. (a) < (c) for happiness, and (a) > (c) for composite MPSS & SEES-PD at T2
Janse van Rensburg 2009a	Within subjects (randomly ordered). Desire to smoke measured at baseline, mid, immediately post treatment and post eye tracking protocol. Abstinence period 15 hrs.	13 M & 3 F. Mean age 29.01 yrs. Mean CPD = 15.5 Non-quitters. Mean FTND = 3.9. Mean baseline Desire to Smoke =5.3 and 4.8 for control and exercise session respectively	(a) 15 min. cycling at RPE 11-13 (mean RPE = 12.7; HR = 135 bpm) b) passive waiting	Desire to smoke. Other measures of attentional bias to smoking v neutral images not reported here (using eye tracker technology)	(a) < (b) Desire to smoke at T2, T3 & T4 (Eta ² ES = 0.64, 0.65, 0.29, respectively).
Janse van Rensburg 2009b	Within subjects (randomly assigned). Measures at pre- (T1), mid- (T2), & 0 (T3), 20 (T4)(post-scan) post-treatment. Abstinence period > 8hrs	6 M & 4 F. Mean FTND = 3.4. Mean CPD = 13.7. Non quitters.	Both 10 mins: (a) cycling, mean HR= 136 (b) passive sitting Both followed by fMRI during presentation of smoking & neutral images	Desire to smoke. Other measures of regional brain activation (using fMRI) in response to smoking images.	(a) < (b) for desire to smoke at T2 & T3 (ES = 1.08) mins post-treatment only fMRI: differences (a) v. (b) in brain activation in areas of interest
Janse van Rensburg 2010	Within Subjects (randomly assigned) . Measures at pre- (T1), mid- (T2) & post-treatment (T3) . Abstinence period >14 hrs	20 (M & F) Mean age = 20.3 yrs. Mean CPD = 12.3. Mean FTND = 2.3	Both 10 mins: (a) cycling (mean HR=124.5 bpm & mean RPE=12.6) (b) passive. Both followed by fMRI during presentation of smok-	Desire to smoke. Other measures of regional brain activation (using fMRI) in response to smoking images	(a) < (b) for desire to smoke at T2 & T3. fMRI: differences (a) v. (b) in brain activation in a areas of interest

(Continued)

			ing & neutral images		
Ussher 2009	Between subjects (randomly assigned). Measures at pre- (T1) and 0 (T2), 5 (T3), 10 min (T4), & 30 min post treatment, first in lab then in natural environment on same day using a remote hand held device. Abstinence period >16 hrs	31 M & 17 F Mean age = 27.8 yrs. Mean FTND = 5.0. Mean CPD = 15.5	All 10 min & delivered by MP3 player. (a) seated isometric exercise. (b) body scan (c) passive	SoD & MPSS	(a & b) < (c) for SoD at T3, T4 & T5 and (b) < (c) at T2 in lab settings (a & b) < (c) for SoD at T2 & T3 in natural environment. (a & b) < (c) for poor concentration and restlessness and (a) < (c) for tension in lab settings (a & b) < (c) for irritability, poor concentration & stress, and (a) < (c) for tension, and (b) < (c) for irritability in natural environment No difference between (a) and (b) at any point.
Arbour-Nicitopoulos 2011	Within Subject (randomly assigned). Measures at pre- (T1), mid- (T2), post- (T3), and 10 (T4) & 20 min post-treatment (T5) Participants undergoing smoking cessation treatment including receipt of NRT. Abstinence period > 3 hrs	6M & 8F, with severe mental illness. Mean age = 50.14 yrs. Mean FTND = 4.7.	Both 10 min. (a) brisk walk (mean HR = 109 bpm; RPE = 10) (b) passive (mean HR=89 bpm; RPE= 7)	Desire to smoke, MPSS.	No differences between groups on any outcome at any time point except (a) > (b) for positive affect at T2
Faulkner 2010	Within Subject (randomly assigned). Measures pre- (T1), mid- (T2), post- (T3), and 10 (T4) & 20 min post-treatment (T5). Absti-	11M & 8F. Mean age = 24.6 yrs. Mean FTND=4.5. CPD=15.2.	All 10 min. (a) brisk walk (mean HR=115.7 bpm, mean RPE=11.9) (b) passive (mean HR = 71.4 bpm, mean RPE = 6.4)	Desire to smoke, smoking topography.	(a) > (b) for time to 1st puff (71.9 v 57.0 s) (a) < (b) for Desire to smoke at T2, but not after controlling for abstinence

(Continued)

	nence period > 3hrs				(a) < (b) for puff volume & puff duration.
Williams 2011	Between subject (randomly assigned) . Measures pre- (T1) , post- treatment (T2) & upon arriving at next destination (T3). Participants undergoing smoking cessation treatment including receipt of NRT	60F Mean age = 42 yrs. Mean FTND = 4.8.	(a) Multiple acute 50 min brisk walks over 8 weeks (3 x per week) (b) Multiple 30 min film viewing over 8 weeks (3x per week) .	Cigarette cravings (5-items using visual analogue scale (0-100)). Affect (ADACL)	No differences in cravings between groups at any time point. At T2: (a) > (b) for energy, (a) < (b) for tiredness.
Elibero in press	Between subjects (randomly assigned) . Measures pre- (T1) , post- (T2) & 20 min post-treatment (T3). Abstinence > 1hr	76 participants Mean age = 37 yrs. Mean FTND=4.6. CPD = 19.7.	All 30 min (a) brisk walking (Mean HR = 125 bpm, RPE = 12.4). (b) Hatha yoga. (Mean HR = 81 bpm, RPE = 8.5) (c) Rest (exercise video)(Mean HR = 77 bpm; RPE = 7.98)	QSU brief, PANAS, & cue reactivity to smoking images.	(a) & (b) v (c) decreased QSU total and Factor 1 (but not Factor 2) only at T2, (a) & (b) v (c) decreased negative mood & increased positive mood only at T2, Only (a) reduced cue-reactivity
List of abbreviations:	AD-ACL: Activation-Deactivation Adjective Check List CPD: Cigarettes per day ESR: Evening Symptom Report FAS: Felt Arousal Scale FS: Feelings Scale FTND: Fagerstrom Test of Nicotine Dependence HRR: Heart rate reserve MPSS: Mood and Physical Symptom				

(Continued)

Scale					
PANAS: Positive and Negative Affect Schedule					
POMS: Profile of Mood States					
QSU: Questionnaire on Smoking Urges					
RPE: Rating of Perceived Exertion					
SAI: State Anxiety Inventory					
SoD: Strength of desire to smoke					
SEES-PD: Subjective Exercise Experience Scale- psychological distress					
SEES-PWB: Subjective Exercise Experience Scale- positive wellbeing					
SWS: Shiffman Withdrawal Scale					

WHAT'S NEW

Last assessed as up-to-date: 25 September 2011.

Date	Event	Description
26 September 2011	New search has been performed	Two new studies added, several excluded studies added, all of main text updated, several studies added to appendix of acute studies

HISTORY

Review first published: Issue 3, 2000

Date	Event	Description
21 July 2008	New search has been performed	Two new studies included, several excluded studies added, background updated, table of acute studies added
21 July 2008	New citation required but conclusions have not changed	Change of authorship
1 July 2008	Amended	Converted to new review format.
22 May 2005	New search has been performed	Three new studies, no change to conclusions.
19 May 2002	New search has been performed	Search updated, no new studies.

CONTRIBUTIONS OF AUTHORS

The original review was conceived, extracted and written by Michael Ussher, Adrian Taylor, Robert West and Andrew McEwen.

The idea for the review was conceived by Ussher, Taylor and West. Ussher was responsible for co-ordinating the review and undertook the search process and data management; including screening search results and retrieved papers, abstracting data from the papers and contacting authors for additional information.

All authors made a contribution to the design, search strategy and interpretation of data. The writing of the original review was led by Ussher with assistance from West, Taylor and McEwen.

The 2005 update was conducted solely by Michael Ussher.

The 2008 review was updated to include a table of studies examining the acute effects of physical activity on cravings and withdrawal symptoms. This evidence was synthesised by Adrian Taylor and Guy Faulkner, in both 2008 and 2011.

In both the 2008 and 2011 reviews Ussher added studies to the main review and these details were checked by Faulkner. In both 2008 and 2011, except for the section 'Acute effect of exercise on tobacco withdrawal and cravings' (which was updated by Taylor), the text was updated by Ussher and checked by the other authors.

DECLARATIONS OF INTEREST

The first author (MU) was involved in the conduct of two of the included studies ([Ciccolo 2011](#); [Ussher 2003](#)).

The second author (AT) was involved with one of the included trials ([Ussher 2003](#)).

SOURCES OF SUPPORT

Internal sources

- St George's, University of London, UK.
- University of Exeter, UK.
- University of Toronto, Canada.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

Cognitive Therapy; Exercise; Randomized Controlled Trials as Topic; Recurrence; Smoking [psychology; *therapy]; Smoking Cessation [*methods]; Weight Gain

MeSH check words

Humans